PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

THE OCTOBER SCIENTIFIC MONTHLY

SEP 26 192

EDITED BY J. McKEEN CATTELL

THE SCIENCE OF ICE ENGINEERING. PROFESSOR HOWARD T. BARNES 289

THE HOPKINS MARINE STATION OF STANFORD UNIVERSITY. DR. W. K. FISHER 298

THE DEVELOPMENT OF AGRICULTURE. DR. WALTER HOUGH 304

WHAT IS EVOLUTION? GEORGE J. DUDYCHA 317

REMINISCENCES OF AN AMATEUR BOTANIST. PROFESSOR FREDERIC T. BIOLETTI 333

THE MUSEUM OF SCIENCE AND ITS RELATION TO INDUSTRY. DR. F. C. BROWN 340

FITTING THE COLLEGE TO YOUR BOY AND GIRL. DR. ALBERT EDWARD WIGGAM 349

THE BIRTHPLACE OF MAN. DR. GEORGE S. DUNCAN 359

THE PEACEFUL PENETRATION OF ATOMISM. DR. EDGAR J. WITZEMANN 363

THE CHEMISTRY OF THE FORMATION OF POISONS IN PLANTS. LIEUTENANT ROBERT E. SADTLER 369

STUDENT HEALTH SERVICES AND MODERN MEDICINE. DR. J. HOWARD BEARD 371

THE PROGRESS OF SCIENCE:
The Thirteenth International Physiological Congress at Harvard University; The Ninth International Congress of Psychology at Yale University 375

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

NEW BOOKS OF SCIENTIFIC INTEREST

A Course in General Mathematics. CLINTON H. CURRIER and EMERY E. WATSON. viii + 413 pp. $3.50. Macmillan Company.

This book includes the elements of algebra, trigonometry, analytic geometry and calculus. It presupposes on the part of the student only the minimum college entrance requirements in elementary algebra and plane geometry.

The Airplane and Its Engine. CHARLES H. CHATFIELD and CHARLES F. TAYLOR. vii + 329 pp. Illustrated. $2.50. McGraw-Hill Book Company.

This volume is intended primarily for persons interested in acquiring a sound knowledge of the basic facts and theories of the airplane who still do not desire to give to the subject the intensive study which is essential for the designing engineer or the expert mechanic.

The Book of the Aeroplane. CAPTAIN J. LAWRENCE PRITCHARD. Second edition. vii + 267 pp. 24 plates. $3.00. Longmans, Green and Company.

This book, first published in October, 1926, attempts to tell the story of the aeroplane in all its aspects. To the present edition the author has added a new chapter on developments in aviation since the publication of the first edition.

Chemistry in Daily Life. SAMUEL GLASSTONE. vi + 250 pp. 21 diagrams. $2.25. E. P. Dutton and Company.

It is hoped that this book will be of interest to the general reader and be useful as a basis for extension, and similar lectures for adults, as well as a textbook for schools, whether chemistry is taught or not.

Origin through Evolution. NATHAN FASTEN. xiii + 456 pp. 75 illustrations. $4.00. Alfred A. Knopf.

The present treatise is an attempt to present the facts of evolution as the scientist sees them, in a manner which can be understood not alone by the trained student, but also by the fair-minded and truth-seeking layman.

New Views of Evolution. G. P. CONGER. ix + 235 pp. $2.50. Macmillan Company.

The author believes that, in spite of many handicaps, we may "take as an initial assumption the view that the world in at least its broad outlines can be understood if we try to understand it."

Manual of the Vertebrate Animals of the Northeastern United States Inclusive of Marine Species. DAVID STARR JORDAN. Thirteenth edition. xxxi + 446 pp. Illustrated. $4.00. World Book Company.

After going through twelve editions this work has now been given a thorough revision and new features have been added. The author has tried to make use of all information available in bringing nomenclature and descriptions up to date.

Some American Medical Botanists. Commemorated in our Botanical Nomenclature. HOWARD A. KELLY. 215 pp. 43 illustrations. $3.50. D. Appleton and Company.

The author of this book, first privately printed in 1914, has written interesting biographical sketches of the most outstanding of the early medical botanists, who came to America during the seventeenth, eighteenth and nineteenth centuries.

The Plant in Relation to Water. A study of the physiological basis of drought resistance. N. A. MAXIMOV. Translated into English by R. H. Yapp. 451 pp. 46 figures. $6.50. Macmillan Company.

This volume contains a balanced summary and discussion of the many important recent advances in this branch of botany, which, in addition to its scientific interest, is of fundamental importance in its application to agriculture.

The Science of Psychology. An introductory study. RAYMOND HOLDER WHEELER. xvii + 556 pp. 68 illustrations. $3.75. Thomas Y. Crowell Company.

The author gives us here an entirely new work based upon laboratory analysis and experimental investigation. Written from the organismic and configurational standpoints, it reorganizes and supplements the material of older books.

The Thinking Machine. C. JUDSON HERRICK. xii + 374 pp. $3.00. University of Chicago Press.

Thinking, Dr. Herrick believes, is as natural a biological process as the contraction of muscles; they are the work of a machine in both cases. If we learn how we think, we may control and improve both the process and the output.

Human Nature and Management. ORDWAY TREAD. x + 312 pp. McGraw-Hill Book Company.

This book supplies executives and students with a readable but accurate statement of how the findings of modern psychology can be applied in managerial work of all kinds.

Outlines of Preventive Medicine. For medical practitioners and students. Prepared under the auspices of the Committee on Public Health Relations, New York Academy of Medicine. Twenty-one contributors. Editorial Committee: FREDERIC E. SONDERN, CHAS. GORDON HEYD and E. H. L. CORWIN. xvii + 398 pp. $5.00. Paul B. Hoeber.

Each contributor to this volume has written of the ways in which his specialty is related to preventive medicine.

Black Roadways. A study of folk life in Jamaica. MARTHA WARREN BECKWITH. xvii + 243 pp. 22 illustrations. $3.00. University of North Carolina Press.

In addition to other considerations, the fact that Jamaica Negroes have not received their due share of attention in folk-lore studies makes this book all the more interesting to students of folk background.

THE SCIENTIFIC MONTHLY

OCTOBER, 1929

THE SCIENCE OF ICE ENGINEERING

By Professor HOWARD T. BARNES

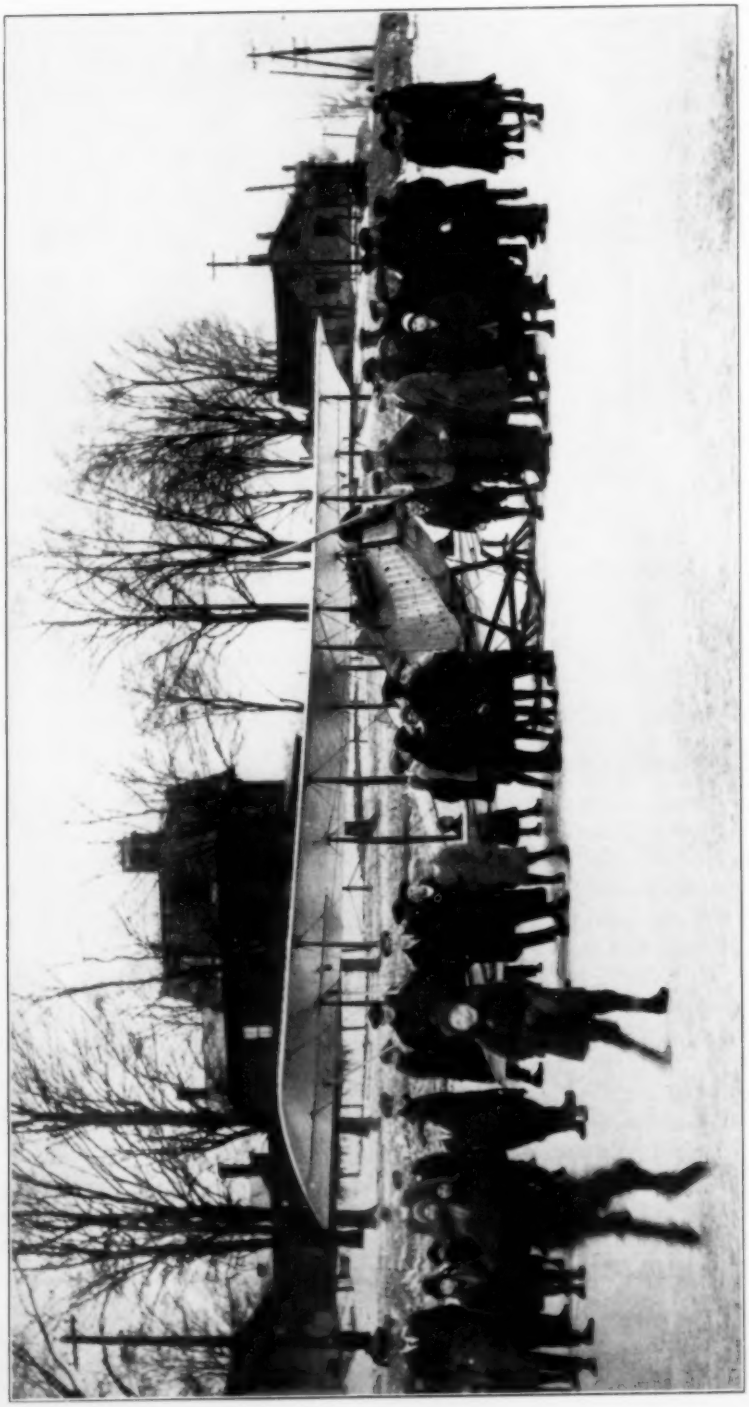
McGILL UNIVERSITY

THE science of ice engineering has as its object the control of ice formations in rivers and lakes, and the prevention or removal of ice jams; the assistance of winter navigation; the control of snow and frost when and where desired; the assistance in the winter operation of power houses; the opening of channels through pen-stocks or power canals, and, in fact, to consider means by which all ice troubles may be better understood and finally solved.

The tremendous cost of ice and snow to this country may be summarized as follows: ice jams with disastrous flooding; shutting down and crippling of power plants; closing of canals and river systems in the north; delays caused by the snow and ice in the operation of railways, motor cars and aeroplanes, and the destruction of telephone and telegraph lines from sleet and snow, etc. To save even a small fraction of the loss in these instances would result in many millions of dollars and certainly justifies the attention and study which may be devoted to it. For the past thirty-five years it has been the writer's contention that a proper scientific study of ice would result in a method for overcoming and minimizing the disadvantages to all northern countries. As the population increases it becomes more and more important to consider these questions, since the full development of the northern areas of the world must depend upon the proper control of ice conditions. While we do not see, at present, any means of altering the climate of the world, we can, by understanding nature's method of ice control, find means for relieving and tempering these facts.

In order to obtain an idea of the fundamental principles of this new science, it is necessary to consider briefly something of the constitution of water and the nature of ice. Röntgen in 1894 was the first to point out that the physical properties of water indicated that it contains ice in solution. It was not until the studies of Sutherland, published in 1910, that a working theory was established showing that the properties of water could be interpreted by assuming that the pure substance known to the chemists as H_2O could exist only in the form of dry steam or vapor; that liquid water was a double molecule or $(H_2O)_2$, and that ice was a triple molecule $(H_2O)_3$, which forms at once as an associative product. Water, then, must be regarded as the mixture of two liquids, the proportions of either depending on the temperature.

As the chemist uses H_2O very freely as a symbol of water, or hydrogen oxide, for international convenience Sutherland gave names to these associated molecules. The simple molecule was called hydrol; the double molecule, dihydrol, and the triple molecule, trihydrol. Dry steam is, therefore, pure



ICE ENGINEERING

IS GREATLY AIDED BY THE AEROPLANE. VIEW OF PLANE USED BY DR. H. T. BARNES, IN 1925, DURING ICE STUDIES FOR THE HYDROELECTRIC POWER COMMISSION OF THE ST. LAWRENCE RIVER.

hydrol; ice is pure trihydrol, and water as we ordinarily know it is a mixture of dihydrol and trihydrol.

Evidence of the theory of the constitution of water is had from the studies of the density of water, optical behavior, specific heat and viscosity. Ice in its solid form has a density of 0.9166, and if it could melt and expand without dissociation like a metal, the density of the liquid ice at 0° C. ought to be about 0.88. Sutherland calculates the varying proportions of one ingredient with the other resulting as follows:

0° C.	37.5 per cent. liquid ice
20° "	32.1 " " " "
40° "	28.4 " " " "
60° "	25.5 " " " "
80° "	23.4 " " " "
100° "	21.7 " " " "
198° "	16.5 " " " "

At the critical temperature, which is about 368° C., water must consist of nearly pure dihydrol, or, in other words, the ice in solution nearly disappears at the critical temperature. It seems evident that the melting-point of ice is not a true physical melting-point but a temperature of dissociation unlike the physical melting-point of other materials.

Colloidal Ice

In considering water as a colloidal solution of ice, there is no microscopic evidence to show colloidal ice particles in water at temperatures above the freezing-point. At the freezing-point, however, the colloidal particles of ice form complex groups of sufficiently large dimensions to be distinguished under the microscope. When a fall of temperature takes place, even the smallest fraction of a degree below the freezing-point, the exceedingly viscous particles of colloidal ice rapidly agglomerate and pass to the true ice crystal.

Microscopic photographs of ice particles as they precipitate from the water show that they are disk-shaped and devoid of crystalline form. The particles, if undisturbed, grow into a form similar to a snow crystal. Various forms of ice are met with in nature, all of which have their explanation in this colloidal theory.

Frazil Ice

In all running streams of open watercourses the most troublesome form of ice is known as "frazil." To the water-power operator it is exceedingly troublesome. With the first cold weather in the autumn when the water comes to the freezing-point there is often a very large and sudden formation of frazil. The explanation of this is exceedingly simple when we realize that the entire body of the stream is nearly 40 per cent. colloidal ice before freezing and coagulation takes place, when the temperature of the water has dropped a few thousandths of a degree. This mass of ice rapidly coagulates into streamers and subsequently into lumps and large clots which are carried in the current to great distances. So abundant is this formation that within a few minutes the whole stream may appear to be loaded with sand. During this time of supercooling these clotted masses of colloidal ice grow rapidly and freeze to any object with which they come in contact.

So delicate is this balance of temperature which determines the sticking properties of this ice that a change of a thousandth of a degree is sufficient to prevent the formation or facilitate the growth of this ice. This delicate balancing of the forces of nature is easily explained when we understand the true nature of the water structure and that the freezing-point of water represents a chemical change rather than a physical one.

During the processes of formation the streamers and curtains of frazil ice form throughout the whole body of the water as fog is formed in air. It occurs with the same suddenness as fog and it very closely resembles it. It is dispelled

THE FIRST THERMIT HEAT UNIT

USED IN LOOSENING AN ICE JAM AT WADDINGTON, N. Y., IN 1925. DR. H. B. FABER SHOWN ADJUSTING THE IGNITION WIRES. DR. FABER ASSISTED IN DEVELOPING THESE UNITS.

almost instantaneously by the light of the sun and becomes very sensitive to small temperature changes in the water.

The light of the sun produces a direct action on the ice particles as well as an indirect action on them by warming the water. There are two ways that the frazil fog can be dispelled: one is through this direct action of radiant energy destroying the agglomerating properties of these colloiding ice particles; and, second, there is the action of the heat in warming the water, elevating the temperature, and thereby mechanically acting on the particles of ice by melting them. Radiant energy, such as supplied by the early morning sun, will loosen solidly frozen ice crystals and cause small ice particles to disappear.

LIMITED ICE-FORMING POWER

Water may be exhausted of its ice-forming power, as has been proved by experiments recently conducted in our Ice Research Institute at Morrisburg, Ontario. In these experiments water in a tank was cooled at a temperature ten to fifteen degrees below freezing. After the expiration of a certain length of time ice was extracted and measured and the water allowed to produce fresh ice for a further period.

As an example of what happens, the result of one experiment showed that the first half hour yielded a full pail of ice. It required, however, a whole hour afterwards to produce another full pail of ice. Two hours more were required to produce a third of a pail. For four hours afterwards no ice was produced. This extraordinary result can be explained on the colloidal theory, but it is difficult in the short space of this article to go into the theory adequately. It is evident that a nucleus is required for the colloidal ice mass, and after exhausting these nuclei, the formation of further ice is rendered difficult. This subject will be treated fully elsewhere.

Warming Water to Obtain Ice

The passive state of water can be explained, also, on the ground that there is a time required for the restoration of the trihydrol in solution and at the temperature of freezing it is considerably slower than at higher temperatures. The active, or ice-forming state of water may be restored immediately by warming the water to room temperature and then cooling, indicating that the equilibrium is established quickly at higher temperatures. We have, therefore, the interesting anomaly of producing ice in water by warming it.

Anchor Ice

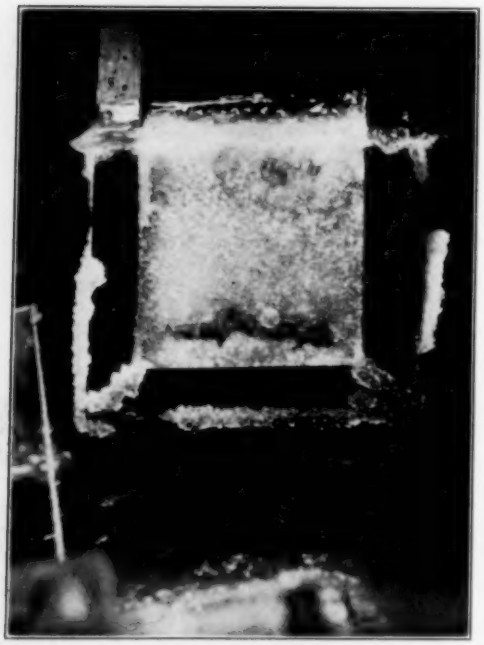
Anchor ice occurs in rapids and streams up to a depth of thirty feet, and depends upon the clearness of the water and the rapidity of flow. It is exceedingly sensitive to daylight, and such formations as occur at night are immediately relieved by daylight. This anchor ice is formed in rapids even when the temperature is considerably above the freezing-point. It forms more slowly with greater cooling in deeper water.

Correspondingly, the melting of this ice is more rapid in shallower streams on the advent of daylight and during very cold weather the anchor ice may remain for several days on the bottom in very deep streams. Thus, we will have on a river a run of anchor ice in the morning from the shallower parts and in the afternoon from the deeper portions, establishing thereby a very valuable dis-

THERMIT DESTROYING ICE

Disintegration of a solid block of ice, two feet cube, by the heat from two and one half pounds of thermit. Phosphorescent ice and heated hydrogen gas rising to seventy feet.

CALCIUM CHLORIDE OPENS CHANNEL IN ICE FOR MORRISBURG FERRY



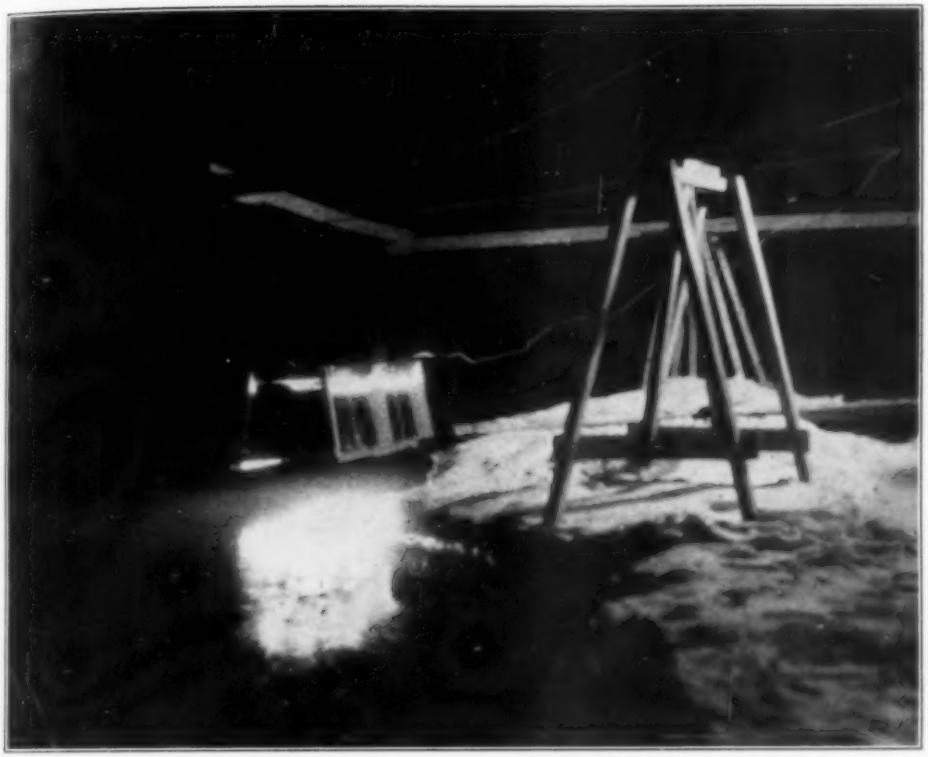
ANCHOR ICE

DEPOSITED ON A PIECE OF WIRE FLY SCREEN UNDER WATER.

tribution of ice flow in an open stream, for the greater abundance of ice from the shallower portion has passed before the ice from the deeper portion rises to cover the surface.

The formation of surface ice is a study in itself and can not be fully treated here. Its growth is exceedingly slow after it has achieved a certain depth, and it is interesting to observe the formation of the crystals of this ice by the accumulation by layer after layer of ice disks on the under side very much like stacked Chinese coins. Very old surface ice gradually becomes coarser in structure, owing to the fact that the large crystals consume the smaller ones. This is noticed also in old glacial snow accumulations. After many years of continual cold the glacier becomes coarse-grained and the snow much more granular in structure.

Of the factors which contribute towards the formation of ice, undoubtedly the most important is terrestrial radiation, causing ice growth by reason of the fact that water is a perfect radiator of heat, and in winter loses its heat faster than it receives solar energy. Wind agitation, surface disturbances in rapids and waterfalls, deficient humid-



FLOOD LIGHTS ALONG RIVER TO PREVENT ANCHOR ICE AND TO LOOSEN FRAZIL

ity and exposed surfaces all contribute their influence to abstract heat and assist the growth of ice.

Counterbalancing these we have the forces of nature which retard the formation of ice, such as solar radiation, radiant heat, reduction of exposed surfaces, warm rain and high humidity. Light is the most active agent, and it is the light rather than the heat of the sun's rays which is most effective, especially the rays of the rising sun which coming through a clear atmosphere can penetrate deep into the ice and water. As soon as the sun rises in the morning the ice production almost stops, and that which has been formed during the night along the bottom of the river rises and floats on the surface.

In developing artificial methods of ice destruction it has been found that the greatest success has been obtained by methods which are similar to those employed by nature. The exercise of brute force on ice has resulted in a distorted impression of how ice should be handled. By the river-man the use of dynamite has always been resorted to in times of emergency, but it has been found conclusively by expert experimentation that high explosives such as dynamite, T. N. T., black powder and nitroglycerine are of very little value, as most of the energy that is generated is shot up in the air, which merely serves to compact the ice more. While very spectacular in effect, all this energy wasted in the air should properly be used under the ice in destroying its strength.

In 1925 the writer came to the conclusion that heat-producing chemicals such as thermit are more efficiently employed.

A NORTHERN ICE PACK

A GOVERNMENT ICE-BREAKER WORKING THROUGH PACK ICE.

Thermit, which has come to be known generally in its work with ice, is not in any way explosive, but when properly ignited reacts vigorously, generating very high temperatures and producing extremely hot liquid steel. This heat causes the ice to split into its constituent parts, hydrogen and oxygen, with explosive violence, and thus the energy of the reaction is confined and held underneath the surface. The oxygen is mostly fixed by the iron of the thermit to form oxide again, while the hydrogen is liberated as a very hot penetrating gas which burns in the presence of air on top of the ice in a sheet of flame. Literally the ice blasts itself.

The writer has developed a number of methods of attack which are based on scientific physical study. These methods appear capable of dealing with any ice accumulation, when relief is necessary to avoid flood damage or stoppage of a power-house. No set rule can be given, however, as each problem is a study in itself and requires a particular

treatment. The skill of the operator, or ice engineer, is the important factor in its success.

Time is a determining element in ice-engineering work, and remedial measures should be undertaken before the trouble occurs rather than heroic efforts to release an ice jam once it has formed. A quiet safe method of destroying ice in a stream at restricted points where jams are liable to occur results in the disappearance of ice long before the spring breakup occurs.

It is possible even to destroy the ice-forming quality of the water before the ice is formed and thereby keep the water in a passive state, but this new method of ice technique is now being developed and it is too early to say what may result.

Materials Used in Destroying Ice

Besides thermit, which is a mixture of oxide of iron and metallic aluminum, there are other chemicals used in the treatment of ice, such as calcium carbide, calcium chloride, sodium chloride, all of which have a powerful action in rotting and destroying surface ice in the coldest weather, leaving it weakened to such an extent that it offers no resistance to an ice shove. A field of ice can be so treated that definite lines of weakness can be established in any prescribed manner. Young ice can be destroyed in a few minutes, and channels opened in proportion to the economic desirability of such work. Charcoal, cinders, lamp black, sand and gravel are also very useful in their way of drawing the sun's heat and aiding in the rapid destruction of surface ice when correctly applied.

In every case where ice of a river is treated during the winter months by these methods the spring break-up may be hastened at least two to three weeks.

The writer has developed recently a new material called "solite" which can be dropped from an aeroplane over a crucial point in an ice jam. Solite is very effective in treating these congested areas not easily reached. It requires no wires or batteries to set it off and may be delayed to any extent that is required, hence it is of very great use in aeroplane work.

Before undertaking a piece of ice-engineering, all information should be obtained by a general survey of the section to be treated; the accumulation of existing data, and comparison with previous records, where they are obtainable; the depth and nature of the ice and the flow of water in the region under consideration; the lines and points of weakness in the ice mass to be considered.

If this work is undertaken early in the season so that the accumulation and growth of frazil is kept away from the surface ice and the water allowed to flow under the ice, serious ice jams and the resulting flood and loss of property can be avoided.

In the same way, if engineers in constructing dams and power-houses would take into consideration their ice hazards, and would employ scientific methods for overcoming them, much of their trouble could be avoided and a great deal saved in the cost of construction. It is estimated that many millions of dollars are lost annually from power structures owing to the want of attention to winter operation.

Many lines of work have yet to be attacked, but the great success already achieved by the new methods is very encouraging for the future development of ice-engineering, and from the keen interest with which the public has followed its development, it is apparent that people are beginning to realize that we will not inevitably have to submit to this tyrant of the north, but that it, as well as many of the other great forces of nature, can be controlled and converted to our use and benefit.

THE HOPKINS MARINE STATION OF STANFORD UNIVERSITY

By Dr. W. K. FISHER

DIRECTOR OF THE HOPKINS MARINE STATION

ROBERT LOUIS STEVENSON aptly compared the curve of Monterey Bay, California, to that of a fish-hook, with old Monterey bordering the sheltered bight at the south. In the adjacent town of Pacific Grove, near the "barb," is the Hopkins Marine Station. Hard granitic rocks interspersed with short beaches characterize this portion of the coast, as well as the rugged littoral to the south. For forty miles to the north of Monterey is a long sweep of sand representing the shank of the hook. In places back of this are quiet meandering sloughs with zostera and a rich permanent fauna of mud-loving animals. Low, pine-clad hills separate the harbor of Monterey from Carmel Bay, a few miles to the south.

Four names are inseparably associated with the founding of the Hopkins Seaside Laboratory in 1892: Timothy Hopkins, David Starr Jordan, Oliver Peebles Jenkins, Charles Henry Gilbert. Back of the obvious desirability of a marine biological laboratory in connection with a new university of great promise, was the example of Anton Dohrn's Naples laboratory, which had greatly impressed Mr. Hopkins, and the Penikese experiment of Agassiz in which Dr. Jordan played a part at a formative stage of his career. The combination of these four men was a peculiarly happy one—all young, enthusiastic, each playing an essential part. So the idea started. After thirty-eight years it is significant perhaps that the Hopkins Marine Station more nearly resembles the Naples Station than it does any of its other predecessors—but with features essential to its organization as part of a university. One of its buildings bears the name of Agassiz' son, and it is to be hoped that those responsible for leading the younger generation have not forgotten the Penikese ideals so ably interpreted by Dr. Jordan.

The present station dates from 1916 and is due to the vision and energy of

THE HOPKINS MARINE STATION

THE JACQUES LOEB LABORATORY AT THE LEFT.

LOW-TIDE AT THE STATION POINT

President Ray Lyman Wilbur, who was himself a student at the Seaside Laboratory. The land and the two wooden buildings of the original institution became quite inadequate. A new site was chosen, which by subsequent purchases was augmented to about eleven acres. This comprises all of what was formerly known as China Point, from the presence of an old and picturesque Chinese fishing village, wiped out by fire in 1903. Near this site stood the old Hertzstein Laboratory in which Jacques Loeb continued work begun at the Hopkins Seaside Laboratory.

In 1917, while the first building was

HIGH-TIDE AT THE STATION POINT

COAST AT CYPRESS POINT, NEAR MONTEREY

under construction, the present name was adopted. This unit, recently designated the Alexander Agassiz Laboratory, is of reinforced concrete construction, three stories in height and approximately forty-three by eighty feet over all. In the summer of 1928 a second unit, known as the Jacques Loeb Laboratory, was completed from funds donated by the Rockefeller Foundation. This is also of reinforced concrete, and as shown by the illustration consists of a central portion of two stories flanked by two wings of one story enclosing three sides of a front court, the over-all dimensions being ninety-five by one hundred fifty-two feet. The building is designed for permanent research in

THE HOME OF SURF FISHES AND SAND-LOVING CRUSTACEA AND MOLLUSKS

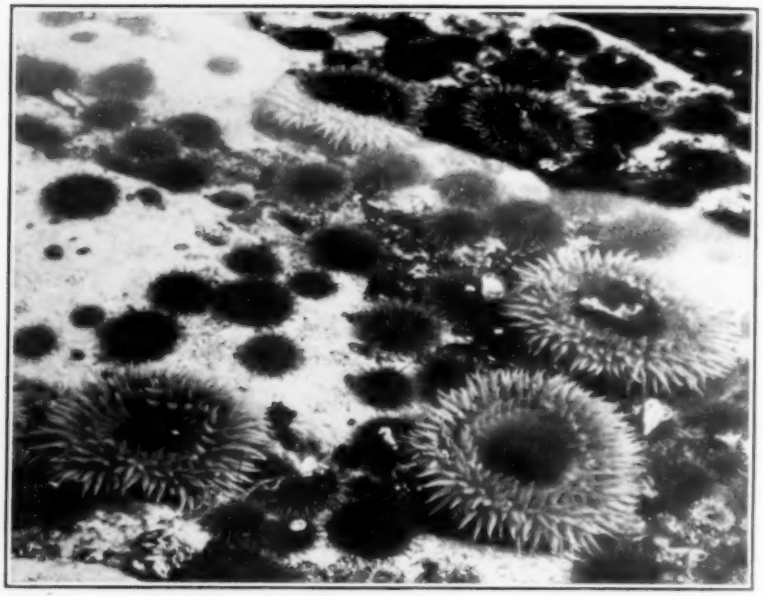
physiology, experimental morphology, biophysics, biochemistry and bacteriology. As a general principle, large specialized laboratories are equipped rather than individual work-rooms, although seven private rooms are available.

The general facilities which are present in nearly every laboratory include: pressure and suction air; alternating and direct current up to 200 volts; battery current to 90 volts. In the large laboratories provision is made to vary the current at almost every outlet, and specially constructed hoods with outlet controls increase the usefulness of the rooms. Sea-water is conducted through antimony-free lead pipes to a reservoir of 10,000 gallons' capacity situated on an elevation of rocks whence it is fed by gravity to the aquarium tables and sea-water outlets in the laboratories. In the construction of this system the use of copper and metals other than lead has been avoided. All aquarium tables are equipped with several air pressure outlets. One room is designed for permanent set-ups, such as potentiometers. There are five dark-rooms, one for general photographic use, three for spectroscopy, polarimetry and photometry, and one heliostat room which derives its light directly from the roof of the building. The principal laboratories and work-rooms are supplied with sea-water, hot and cold, fresh water, distilled water, gas, in addition to the current and air outlets mentioned above.

THE RUGGED COAST SOUTH OF MONTEREY BAY
TEEMING WITH ROCK-LOVING SPECIES

The older building, the Alexander Agassiz Laboratory, houses those of the staff concerned with the hydrobiological survey of Monterey Bay and with the more traditional lines of research in zoology and botany. This building also contains the general laboratories in which most of the undergraduate classes are held during the spring and summer quarters.

Since 1918 the station has been open during the entire year, and it now maintains a resident staff of eight specialists in addition to three technical assistants, a secretary and a mechanician. The permanent staff is augmented during the summer by members of the school of biology of Stanford University, and



PURPLE SEA-URCHINS AND GREEN SEA-ANEMONES
A CHARACTERISTIC COLOR COMBINATION.

usually by a few biologists from other institutions. The staff tenders facilities to visiting investigators, furnishes graduate and undergraduate work in biology and maintains a permanent program of research.

During the last two decades it has grown increasingly evident that the biologist can no longer pose as a physicist, a chemist, a bacteriologist; nor is a successful anatomist, embryologist, taxonomer and oceanographer likely to reside in one person. A research institution committed to hydrobiology, oceanography and the multifarious ramifications of experimental biology can not function without the aid of specialists.

An enumeration of projects under way or planned for the immediate future would suggest the scattered blocks of a mosaic rather than a finished picture. The research program in a general way concerns itself with oceanic biology. This work includes a hydrobiological survey of Monterey Bay which is being carried out with the cooperation of the California Fish and Game Commission. Special attention is being paid to the relations between the organism and its environment, including a consideration of the composition of sea-water in relation to equilibrium with solutes. The developmental histories of fishes having pelagic eggs is being given major consideration, as is also the ecology of plankton organisms. A factor of prime importance is the close proximity of depths as great as a thousand fathoms. It is therefore confidently expected that the physiology of pigments and luminescent matter of deep-water organisms and certain features of the ecology of these same creatures will be available for study in the near future. The physiological program comprises the characterization of the environment in relation to varying groups of organisms, more especially those living in an abnormal environment. The project includes the determination of the limiting conditions of life and of various extreme circumstances in order to learn something about the meaning of the so-called normal environment of the ocean. General problems connected with marine bacteriology occupy the attention of a

specialist, while another is concentrating on a spectroscopic study of various natural pigments. Band spectroscopy, especially when applied to the living cell, has proved to be a powerful tool in biological research. Work in progress in organic chemistry includes a study of planktonic oils and fats, their decomposition products, both aerobic and anaerobic—in short, their position in the natural cycle of the ocean.

The proverbially rich fauna and flora which are readily available at low tide offer big returns to the investigator and beginning student alike. With such an environment the dyed-in-the-wool zoologist and botanist are at an advantage. The wealth of forms is in part due to the hard granitic rocks, the diversity of exposure, the cold water and the rich assemblage of micro-organisms of the open sea. Many animals are permanently attached, or have dug in, and must have their food brought to them by the water. Groups which especially give character to the fauna are the sponges, anemones polyclad, nemertean and annelid worms, sea-stars and sea-urchins, bryozoans, mussels, chitons (upward of fifty species) and gastropods, the higher crustacea and compound tunicates. Dorid nudibranchs are conspicuous for their size and brilliant color. The plankton of the bay runs the gamut of the animal kingdom from a varied mob of protozoa to salps. Diatoms are very abundant, and the growth of shore algae is lush, often a nuisance to the zoologist, including a wide range of forms from the giant kelps to tiny species which grow upon them as do epiphytes upon tropical forest giants.

Excellent material is available for research in cellular biology, normal and controlled development, experimental morphology, anatomy and taxonomy. There are so many problems in the natural history of shore and plankton forms, both invertebrates and fishes, as to defy enumeration. Fundamental taxonomic work remains to be initiated before much good material for experimental work will be available. As the hydrobiological survey progresses opportunities will increase for highly desirable studies on the ecology and special physiology of deep-sea plankton organisms. The harvest is big but the harvest hands are few!

THE MONTEREY CYPRESS

THE DEVELOPMENT OF AGRICULTURE

By Dr. WALTER HOUGH

THE U. S. NATIONAL MUSEUM

THE period of culture at which men gather together into communities is necessarily variable. It will be seen that it may depend upon the stage of advance, natural mental or physical qualifications, favorable or unfavorable environment, war, disease, repression by neighboring peoples and other causes that may be recognized. With all that can be placed on the debit side it is found that overcoming all suggested obstacles the condition of solvency appears with agriculture. The difficulties of the struggle upward perhaps can never be known and it is necessary to gather illuminative data from tribes that might or might not progress on lines of advance. Therefore a long period may be predicated before man reached a suitable field where agriculture could be developed. There enter here also the requirements of the environment suitable for the cultivation of the grain and food plants in possession of the farmer.

LAW OF HUMAN NEEDS

One portion of the law of human needs is that man must have food on the spot. Obeying the law, man has subsisted on a variety of diets, depending upon the place where he is at the time, taking nourishment from the game of the waters or land, or being frequently a vegetarian of a rather strict sort. Thus when man's diet is examined into it is found that he follows out what physiologists say about the evidence of his teeth, that he is omnivorous. When the need comes strongly to the front anything edible is acceptable. For this reason the subject of diet is important in observing the habits of the races of man. Mostly this is a curious and somewhat superiorly amusing topic except to scientists who are compelled to look beneath the surface for the explanation of, for instance, how and why man became a farmer.

It is seen at once that not all men became tillers of the soil and that opportunity did not come uniformly to the race, because many tribes in the world have not yet graduated to the ancient art of farming. This is because, as will be brought out, there were so many hindrances on the way up.

While it is evident that the early farmers began agriculture on continental land areas, and as pointed out by Payne, of Oxford, under semi-desert conditions where the repressive effects of exuberant vegetation are not present, its discovery was greatly delayed when we consider the migrations of groups of men through a long period, before the proper environment for the practice of this art was reached. In the early period we must imagine that environment was not yet effective as a factor more or less potential in its interactions of man and conditions. It is logical to suppose that man migrated in search of environments favorable for his well-being, moving on and leaving fractions that were stationary on grades of food supply below the agricultural level or that present mixed phases of agricultural and feral subsistence. Examples in point are a primitive dependence upon fruitful trees and other plants furnishing food, fiber and other necessities, this phase exhibiting what may be called unconscious cultivation. The agave and cassava were important subsistence plants in primitive America long before maize and it is probable that the date palm growing much antedates the use of any cereal.[1]

[1] "The Palm and Agave as Culture Plants," Internat. Cong. Americanists, Quebec, 1906, pp. 215–221.

Conditions of Subsistence in Pre-agricultural Times

At no time and in no environment is observed a purely animal subsistence. In ice and tropical areas, if it is allowable to cite the habits of peoples living in the high north as evidence, the food intake was mixed animal and vegetal. This fact is reflected in the mixed dentition of man and is also evidence of the development of practical means to insure the perpetuation of man by habituating him to subsist in environments unfit for other animals confined by nature to a type food supply.

The food supply of the native inhabitants of a north and south extending hemisphere, as the New World, is readily analyzed.[2] The east and west lying Old World presents different problems more complicated by nature and more varied, owing to the phases of domesticated animals and the possession of the major grains.

Nature being so tremendously prolific in things not needed by man and chary of things he can use for the higher economics, it appears that root crops, mostly poisonous without treatment by fire, do not furnish a reliable basis for a populous or permanent civilization. It is true that we find in the West Indies and a vast area in South America what may be termed the cassava culture based on the root of the *Manihot utilissima*, but even in localities where maize is an adjunct there has been produced no civilization of importance in the progressive history of man.

Similar conclusions must be stated in regard to the races subjected to meat and fish diet. These, it will be observed, present interesting phases in the dietary and economics of various races, but aid little in the floriation of culture. Such diets are characteristic of some of the sidetracked sections of humanity compelled to observe the food law of nature and to glean with hard labor their isolated lands and sea for something to eat.

[2] "Handbook of the American Indians," Bull. 30, Bur. Amer. Ethnol., Article: "Food."

Lines Leading to Agriculture

Presuming largely that agriculture became effective at the stage when the populations of favorable regions reached a density that demanded a stable basis of subsistence, it is possible to affirm that the art of cultivation arose comparatively late in the scale of human progress. In fact, agriculture began, so far as the definite cropping of cereals is concerned, in the Neolithic, the earliest date assigned to this period in any area being 8,000 B.C. Before this time humanity did not depend upon this basic industry of farming. Agriculture, then, may be said to mark the beginning of permanent and incalculable progress.

As with inventions that are seen complete in the hands of man, one is tempted to conjure up some genius who discovers agriculture, but on reflection this is too easy, not to say the lazy way, omitting the long and painful steps of progress that must be taken before an invention can be perfected. As to the origin of invention, Greek philosophers and other wise men must have waved their hands at the crux and attributed it to Daedalus or like worthy.

Development of Food Plants

Agriculture had a beginning, though its earlier stages are not recognizable in the terms of present agriculture. It is necessary to regard the progress not as a definite aim, but a development involving many factors, some of which are pointed out, and coming to a consummation recognizable as agriculture with the cultivation of grain-yielding plants such as rice, wheat, oats, barley, rye and maize, and the less economically important but highly valued leguminous plants as beans, peas and the like. The obscurity covering the history of the domestication of these plants is not rivaled by that surrounding the "lost arts of the ancients" of literature.

No attempt is made here to follow out a theoretical scheme as to the development of plants for economic use. It is understood that plants capable of agriculturation were finally selected and planted and brought forward in yield, pursuing the methods and deadwork of clearing, tilling, watching, representing the great labors antedating the harvest. It is surmised that the cereals were selected during the period of wild harvesting and that plants showing fruitfulness and perhaps a desirable flavor were planted when the agricultural phase of culture began to take on importance.

The question whether the agricultural method arose independently with each basic cereal can be with confidence answered in the affirmative.

On this topic the agriculture of maize in America is a conclusive argument. This strictly American cereal was brought to economic perfection by indigenous methods which conform to those applied to cereals in the Old World. The origin of maize cultivation in America is quite as obscure as is that of such basic crops in other parts of the world. Here in the western continent the rational developments observed elsewhere are evident in the rise of advanced civilization under the tutelage of maize.

Selection of seed is well understood by aboriginal agriculturists still retaining the older phases of the industry. This feature was no doubt learned quite early, and largely by it agriculture of grains acquired more importance in furnishing requisite amounts of a chief staple that could be stored from harvest to harvest. The experimental selection of seeds over a long period gives in the result what Burbank accomplished in a few years by using the scientific mind on the experiences acquired by plants in the course of their life history.

Environmental Conditions

In the laboratory of nature plants come to represent the various reactions arising from favorable and unfavorable correlations in the environment. They reflect in their structures the good or bad treatment they have received in the past. In associations with man undesigned contacts are observed to be favorable to plants. About the habitations of man in unused spots weeds flourish more luxuriantly than in their natural areas. In an enclosure, vegetation normally repressed by soil or animal enemies flourishes and, as around the domicile, begins in some cases to leave off its feral protective devices. In a garden competition of wild plants with the desired crop becomes at times fierce, especially in regions where the rainfall is depended upon to get results.

Personal observations in Mexico of village communities give the impression that in the scattered houses each with its little plot of ground we have a picture of the early grouping of man, a laboratory favorable for carrying out designed and unintentional experiments with plants. In one place a spineless cactus (Opuntia sp.) was observed in a dooryard, a proof of Burbank's thesis that plants react to protection. In some such condition the ancestor of maize may have shown variations which attracted the early gardeners. About 1914 the teosinte plant of Mexico was put through a short course by Burbank and made to produce ears of naked grain maize.

Plants coming into close contact with man begin to exhibit potentialities of usefulness not disclosed by the same species in a feral state. The plants that will be useful begin to show variations in the way of better fruits and the casting off of disadvantageous acquired protective devices.

At this period in human culture characterized by a relatively great progress man focused upon plants the same knowledge which he had derived from his observations on the habits of animals, that is, had collected the data necessary for their capture. In the phase when

animal subsistence was important the characteristics of animals were known, being essential to his existence. It may be said that the animals that would subsequently be domesticated were already known on account of their habits to men of the loosely classed hunter stage.

Incidentally, the uncivilized tribes are sometimes not given credit for the vast body of knowledge that they possess on the plant life of their environment. Only in recent years has this line of scientific inquiry been given the attention, not at all adequate as yet, which it demands.

The Hopi Indians have what seems to an outsider a pretty conceit when they name a plant "the Mole his corn," "the Field-mouse his corn," and the like, but in reality there is disclosed here the keen observation of the Indian on the natural subsistence of animals. How much this has aided native men in the selection of plants is speculative. On the other hand, the relation of animals and plants is an interesting study, in regard especially to the modification of species through the ministrations, or undesigned agriculture, of animals. It is evident that plants have been brought far along the road by other forms of life. When man took them up for practical purposes beyond any previous uses, plants had diversified in such characters as fruitfulness through the aid of insects and other helpers in the wonderful partnerships of nature.

It is probable from the above considerations that agriculture, which is now regarded as productive principally of cereal crops, was confined originally to garden plots to which plants more or less useful to subsistence were intentionally brought and tried out. Here it may be conjectured most of the vegetables, small fruits, trees and so forth accompanying farming were developed further. The cereal destined to bring the crop of the highest economic importance to the greatest number of mouths doubtless derived from but did not supersede its humbler companions.

Methods From Hoe to Plow Stage

It is understood that there will necessarily accompany agriculture from the primitive stages to the most advanced certain essential tools. These tools, representing with reasonable clarity the progressive stages of agriculture, are the digging or planting stick, the hoe and the plow. While these are concerned with getting the crop in the ground, caring for it, and are among the myriad of devices growing around the needs of agriculture, they are tools of almost universal use, affording a means of grading the races of planters.

The digging stick came into agriculture from early periods when it was of general utility for digging out game from burrows or other excavating work and for many other purposes, even as a weapon. It is possible that a stick was first aid to primitive man.

In America the agriculture of maize requiring the planting of the seed in hills rendered the digging stick an essential tool peculiarly adapted to this work. The Hopi and other Pueblos retain this primitive tool to this day. Apparently among them the hoe was introduced through the Spanish conquest and found its chief use in clearing the desert fields for planting. An intimate personal possession of the farmer, the Hopi regard this digging stick as a symbol of support and reliance in life and death. The digging stick protruding above ground at the head of a grave denotes a guide for the spirit in making its way from the piled-in earth.

The usual Pueblo digging stick is a stave of strong wood worked wedge shape at one end, and beyond the smooth human wear has no other modification. The Zuni expand the end of the stick into a blade and work out a crutch for the foot in forcing it in the ground. The digging stick here becomes a spade

worked in a standing position, while the farmer sits or squats on the ground in wielding his stick, indicating a more primitive method. In the Salt River Valley the early irrigationists used a blade-like digger, and in cliff dwellings and other sites sword-like digging sticks have been found. A weighted digging stick for getting out roots, the weight being a perforated stone, was used in California and is observed in South America and other parts of the world where root subsistence is important.

In general it may be said that the digging stick is not in the line of the ancestry of the hoe, and the method of use is quite different, the former being a vertically thrust-in and piercing implement and the latter delivering a horizontal blow like a pick or adz.

The hoe is more strictly an agricultural tool adapted to the cultivation of plants in tractable soil. In method it is used more as a horizontally mounted shovel, drawing the earth into the beds or ridges formed in eastern Indian maize culture. It thus suggests the ancestry of the plow. The digging stick proves its usefulness in hard soils and in the obstacles of fire clearings, while the hoe follows in working the loosened earth. It is likely that the breaking of fields for the crops of European-Asiatic grains was exclusively accomplished with sharpened sticks. In archeology the hoe is in evidence only when the material is stone, while the perishable materials, such as wood, bone, etc., have disappeared. Therefore the distribution of hoe culture can not be outlined by the stone implement. Also in many localities the proper stone for making hoes does not occur.

It will be seen that the digging stick and hoe belong to the period of small plot agriculture and only after the increase of population with the accompanying needs does the plow appear. It is evident that the plow comes into use late in the history of agriculture. Its use also marks the beginning of a great period in agriculture. The use of the plow was sporadic in contrast with the general distribution of the digging stick and hoe. Only when the conditions of increase of population and social organization became important enough would the plow be developed. The plow also means more land put into crops, more mass effort and some hitherto unneeded form of traction.

In the picture of wide-spread agriculture before the age of invention it would seem that the plow was invented independently in many places. There is, however, little reason for setting this forth as a scientific conclusion. Nothing like the plow beyond the hoe was ever invented in the western hemisphere. The Europe-Asia-Africa complex is sufficient to explain the diffusion of the plow to these continents together with the conditions for its use as suggested. The rise of the plow in the ancient Near East civilizations is borne out by the conditions which made them civilizations. Improvements on the simple plow are evident in the long stretch of time from the dragged pronged stick to the perfected implement of the present.

Unfavorable Locations

In the spread of agriculture by slow infiltration to favorable land there must have been many disappointments as to soil and the idiosyncracies of plants. The manner of established and combative growths has always been the bane of the general diffusion of agriculture. It is manifest that agriculture does better in nature cleared desert lands than in fields burned or hewn out of the forests. Agriculture in forested lands before the advance of agencies of power in the inventive epoch and hand tools, as the steel ax and grubbing hoe, was a painful and losing adventure. The Mayas coming to Yucatan were forced to employ milpa agriculture, that is, the clearing of fresh areas of forest constantly as the older

fields were captured by vegetation, principally grasses which resisted the primitive methods of cultivation employed by the natives who lacked also grazing animals to keep down the growths. The growing distances of the fields from the population, the transportation of crops and the labor of clearing were met by the Mayas for centuries, during which they developed their wonderful civilization, but eventually these conditions conquered them and reduced them to the jungle state in which they now exist.[3]

There are many examples of such misfits of agriculture like the above which add grievous burdens to the already hard load put by ordinary conditions on the business of agriculture.

Generally by endless experiments agriculture has accommodated within certain limits plants to various regions to which they were not formerly adapted. The tendency to display new characters in plants undergoing cultivation, a habit called variation, has aided in the spread of agriculture.

In this process it is found that plants forced far into variation lose the feral qualities that enabled them to live in their environment and are compelled to depend for their propagation on human agencies which preserve the seed. Many economic plants have been so altered by variation that if it could be imaginable a total loss of seed would render the plant extinct. This applies to grains, but other plants, as the banana, losing their seed by cultivation must be propagated by slips. Thus many plants are dependent possessions of man, who may be represented as repeating the modifications on vegetal life due to insects and these in turn modified by the wonder-working process of variation.

The spread of useful plants may have been influenced by an observed psychology of those engaged in agricultural pursuits. That agriculture was a softening process on man is evident, reducing him to a static position upon the land with a perishable or transferable stake easy of access to marauders and inculcating peaceful habits. Agriculturists are for these reasons averse to war and are forced into conflicts by the ruling grades of social organization, which dominate but are dependent upon agriculture. This preface is to bring out the comity between farmers, leading to the interchange of plants and seed, thus tending to the general diffusion of materials and methods. Farming from its nature could not be kept secret like some of the arts. The precious seeds of corn mythically given by the gods to the Zuni could not be long a tribal possession. The spreading of seed is a human urge.

[3] O. F. Cook, "Milpa Agriculture." Smithson. Report, 1919, pp. 307–326.

Domestic Animals

The domestication of animals in its relation to agriculture appears to follow normal lines of growth of both industries. The coalescence of animal and crop husbandry was early and was preceded by phases where conditions were more favorable for grazing than tilling or *vice versa*. Both animal and plant domestication, apparently results of the application of the same principles, were in fact completed in the Neolithic in a region where the two progressed together, so that in the first glimpse of farming we find man dividing his efforts between flocks and crops.

Here and there is observed the ancient fission of the herder and farmer which obtains to this day. This is for the reason that the herbivorous animals require a wider range than the smaller animals which are in closer association with man. It is seen, however, that in the small farming of parts of Europe, probably typical of the Neolithic phase, and in many respects a survival, there is a division of labor producing the classes of herders named gooseherd, goatherd, cowherd and the like, acquainted with the habits of their respective charges.

The domestication of the horse, an animal useful in the early times only as food, appears to have had an important bearing on the completeness of the taming of the large herbivores. This statement is based on the probable first economic use of the horse as a riding animal in rounding up cattle. In this accomplishment it must have been learned by daring spirits that a horse could be broken. The horse as a traction animal came late in agriculture in matter-of-fact lands where the age-long affection, almost worship, of the horse was not prevalent.

The economic results that came from the combination of tilling and rearing were of manifest importance. Industries not dreamed of in the preceding periods have extended to enormous proportions on the animal side of husbandry. It is not supposed that in the agriculture of centuries ago animals were recognized as consumers of crops produced by hand labor, yet there were no doubt seasonal crises when feeding was obligatory. It is seen that feeding grew slowly towards the present period when a large proportion of the crop is converted into meat.

This development has not been uniform in all countries or in the same degree. Chinese economics, for instance, had to choose between animal and human population. This brought about the practical elimination of the larger grain-consuming mammals and the substitution of the smaller mammals and fowls more or less self-supporting or feeding on offal. This feature is observed where agriculture entrenched on the larger areas required for grazing. It is probable that with the increase of population and consequent crowding in the United States and Canada history will repeat itself. There are symptoms now of a coming change in the diminishing consumption of red meat.

Conservation and Preparation of Food Supplies

Having sketched the chief phases of the development of agriculture, attention is now given to the outgrowth of an established system of tilling serving a constantly increased population. Storing, preparing and serving the food products of agriculture necessarily had their roots in a small way in the beginnings, even extending to the pre-agricultural phase. Whatever is acquired from the jungle or results from crops and fields has upon it the necessity of preparing it for future use in times of scarcity or between crops. This is the foundation of economy, the central motive in agriculture in contrast with the more or less mythical hand-to-mouth customs ascribed to inferior races.

Possession implies disposal. Each class of gathered food material requires its own process of preservation. The story of the preparation and storage of human aliment is so vast that only the salient points may be hinted at. As to animal food, the savage may be imagined as making his kill and placing the meat in contact with his digestive fluids as soon as possible without thought for the future.

A step forward and we have drying meat for preservation and later the employment of the first chemicals in smoke for more complete preservation. This satisfies the needs for a long period until the value of salt as an agent is discovered. Following on into later and modern periods it is seen that all the resources of the phenomenally advanced sciences are employed in the various conditions developed.

Vegetal food supply also presents many problems of preparation for preservation and storage. Root and tree crops exhibit methods of preparation by drying, the use of heat to alter toxic properties, as in breadfruit and cassava. The latter is put through the process of grating, pressing and baking to yield a storable product. Fruits are dried or worked over for putting away. Portions of edible plants are dried and stored by methods found suitable.

The introduction of cultivated grains into the dietary made for less prelim-

inary preparation of the crop and furnished less perishable materials for storage. The earth cache method appears early among the grain-raising peoples. Aside from bulk the grain pits of Ur of the Chaldees differ little from the cement elevators of the present, and both take their origin from the original and nearest available storage places in the earth.

There comes to view here the vast field of human endeavor in the agencies connected with the serving of food. The milling industry from the period when many farming operations were carried on by individuals shows at first the millstone and hand stone between which grain was broken for further processes. The primitive millstone accompanied the agriculture of grains over the world and in pre-agricultural times had its beginning use in crushing grass seeds and hard substances.

The mortar, ancient but not so primitive as the milling stones, also became an adjunct of the grain farmer. In the maize-raising area the mortar has a rather remarkable distribution. In the original home of maize milling was practised on the metate, an implement requiring workers to sit on the ground, a position, as has been stated, characteristic of primitive industry. On the spread of maize culture to other environments, especially to those of rain irrigation, the mortar appears. This is shown by the presence of a primitive metate in the semi-arid southwest on the boundaries of Mexican culture and the prevalence of the mortar in other parts of the United States.

The meaning of this distribution may be suggested by ancient and developed economy of the maize growers of the south which required fine flour and that of those who more recently acquired maize and practised ruder methods. In general the Indians of the rain-watered lands ate corn boiled as hominy or coarse mush bread for which the incomplete cracking in the mortar sufficed. Thin breads were unknown to the Indians north of the metate area. On the other hand, the standing posture of the mortar worker may indicate a preference for this working posture induced by the environment. While some consideration should be given to the presence or absence of mealing stones in some areas, a general view of the different habits in the larger areas does not give much weight to this suggestion.

In considering the mill for grinding grain it would appear that the concept of rotary motion with all its implication of tremendous future advantages was a development in a sense so unnatural or out of the line of animal motions that it came late in the achievement of culture. Thus the employment of rotary motion in the mill marks an important, almost radical, division between the culture history of the hand epoch and the epoch of machinery.

The mill appears in the naked, hard-grain areas of Europe in the Neolithic. Its use is not indicated in the rice area where the mortar alone is effective in hulling the seed. The western hemisphere, whose only grain was maize, developed no rotary mill.

Involved in the various lines of progress growing up with agriculture is noticed the effect of the means of serving food on the industry. Man generally has sensed the need of cooked food responding to his development as a creature, requiring that his food be assimilable. Nature furnished man with many forms of vegetal and animal foods edible without cooking, but not in many cases important as a basis of mass population.

With the agriculture of grains uneatable until put through various processes of preparation, it will be seen that several inventions are necessary. Incidentally, the parching of wild and early cultivated grains was probably the most ancient solution of the problem, continued among some tribes to the present along with boiling and baking of bread.

As with roots and other intractable foods, the pit oven was perpetuated in the roasting of maize. For boiling and other cooking processes pottery was necessary, and this art was contemporaneous with the permanent establishment of grain tillage. Pottery began along with farming in the Neolithic and its upgrowth solved problems at that time and continued with ever-increasing importance in later periods.

Military and Technical Organization

Beside the raising of crops and all the accompanying features of their preservation and disposal, the social and scientific by-products of an agricultural state are numerous and important. It is evident that a new problem of labor was uncovered and that it was quite different in amount and regularity from the sporadic, apparently unorganized work of the hunting or mixed preceding stages in which the family unit alone was to be supplied. The family supply in essence remains the fixed purpose of agriculture to the present, and this, as will be shown, has an important bearing on the regulation of agriculture on industrial models.

In the higher social organization at which agriculture as a general economic feature of life begins, it is seen that labor may be furnished by clans or other bodies associated by mutuality, such as relationship, religious ideas or predatory leadership or, as is general in clans under present observation, a combination of the first two. Theoretically and based on conditions observed in higher organized agricultural societies, some students considered labor as a commodity apart whose necessity was felt in the older social organizations.

That this is an error is shown in clan or communal labor. The Pueblo Indians produced a remarkable civilization without a labor problem in the sense of a separate body of enslaved or dominated workers. This is an example of a peaceful development in an isolated environment.

It appears that this state of affairs was quite wide-spread until there was superposed on agriculture directional orders of society exerting religious and military domination through rulers. This introduces the protection feature, many times necessary in itself but really based on the taxable values established on the land by farmers from which means could be drawn for aggrandizement of the ruling class.

It is argued that as agriculture demanded a fixed dwelling or sedentary life, there was frequently required in this stage a system of protection. In establishing this feature there were sowed the seeds of important human organizations developed in the social forms termed labor servitude, military and religious rule.

The organization of society growing at the top and diversifying its activities produced other orders of consumers based on agriculture thereby increasing the pressure on the land for the food supply. The labor problem kept pace with these developments and there came in the ancient nations devices such as the drafting of labor, slavery through conquest and the binding of labor to the land.

Nothing has been said as to the partition of the soil in agrarian communities. When land is held in common the rudiments of division also exist in the assumed rights of ranking families in the clan, the priesthood in assigning land, the strength in workers in families and other conditions which destined an ideal division. In general, under the clan system rights are acquired by former working of the land and announced intention of working the coming year. In case of failure to work the tract clan law throws the land open for use.

Development of Germane Arts

Agriculture as a basic industry on which stable and growing populations

must exist also aided in bringing about the most considerable advances in social life that may be noted in the progress of man. Some of these features having largely their origin in agriculture may be mentioned.

One of the earliest requirements of growers was a knowledge of times and seasons. These desiderata were undoubtedly acquired over a long course of observations on the heavenly bodies during the domestication of food grains. Out of this knowledge grew primitive astronomy, gradually showing a marked advance in applying crude mass metrics, developing into calendars. All ancient calendars had basically reference to agriculture.

The use of mathematical ideas expressing crude metrics of areas and amounts also evolved in agriculture and mark the unfolding of arithmetic and geometry. Engineering more clearly is a consistent outgrowth of agricultural operations. The earliest forms of this science are found in the selection of ground, clearing of growth involving primitive deforestation and timber work, grading, canal cutting, regulating water supply, and many other engineering jobs coming up in the exigencies of farming. Supplying also the labor to carry on the common and the outstanding engineering work of the world is not the least of the contributions of the farmer to the world's progress.

The participation of the farmer in the technique of commerce is observed to be small. In the early stages before the social complex began to take over the disposition of fruits of the farmers' labors as seen in the agricultural despotism of Egypt, Mesopotamia, China, Mexico and Peru, for example, there was nothing but folk commerce. At the best of the commerce of the ancient world there were inadequate facilities for the transport of appreciable amounts of foodstuffs to supply any considerable populations. There was also no real surplus, only a forced surplus whose export under despotic rule disregarded the needs of many.

The nature of man as a religious creature has caused the permeation of agriculture from the very beginning with lore, myth and observances to counteract the maleficent influences which render the art of tillage a game of chance. A glance at this vast field presented in Fraser's "Golden Bough" reveals the enormous penetration of religion in agriculture, its development there and its response to human needs of protection and guidance.

The above are some of the important features of civilization fostered under the stable conditions afforded by agriculture. It is, however, not supposed that these matters were brought to a state of enlarged usefulness by the farmer alone. The surrounding of the industry by religious sanctions and official controls furnished groups of men having assured subsistence and consequent leisure, who perfected them. The agricultural body with its preoccupation, its lore and crude laws of behavior remained in general ignorance. Agriculture has always been guided in all matters beyond the custom-honored technique of art.

State of Repressed and Dependent Population

When agriculture comes up into the view of history it is seen that society has extended to comprise a number of different orders from slave to king. Society growing from diverse efforts to produce coherence by rule has become in the classic examples a workable form. Division is on the line of intellectual and predatory employments on the one hand and manual employments on the other. The superstructure hides the primitive foundation.

The recognition of what are loosely called rights in common, realized to a great extent in ancient communal effort, was long in coming in more complex

society. The state of repressed populations up to the age of enlightenment was generally unfavorable. The beacon of education and the ability and means of making betterments were denied them. The farmer whose prime incentive was to support his family by the sweat of his brow remained generally in the low level which tradition and sanctions had assigned as his lot. In theory in Egypt the higher classes were "gentlemen farmers," even the Pharaoh being commanded by Ra to work the fields. Examples of organizing ability were no doubt frequent among the farmers in the theocratic government of the country, but farm labor was repressed. In 10,000 years and with all the various social forms developing, which may be called in the nature of experiments, the problem of the farmer has never been solved. In all the cataclysms that swept away the dominant and dependent classes the farmer stayed on. Mounds of earth are the gigantic cities of Mesopotamia and around them the farmers still work the soil with the tools and methods of the far ancients.

This represents the static condition of Asia. In Europe forces were growing that would lead to the emancipation of the farmer from the serfdom binding him to the soil. Here and there the voice of the repressed became heard and finally in Great Britain found that he was a unit of the state, exercised his crude power and secured certain rights. This was only a few hundred years ago, but the seed planted was destined to fruit in the wide lands of America and flourish in a way impossible in the narrow population-crowded lands of Europe. In America the farmer has never felt the repression of geographical and social conditions long the rule in Europe. Military, despotic, patriarchal and religious dominations did not enter into the American experiment. The turning-point of agriculture was in England, but the realization of its possibilities was in America.

Appearance of Surplus

The preparation of crops for market was an almost unknown factor in early agriculture. The germs, however, existed in the beginning stages when some sort of sporadic exchange was carried on. It is seen that the economic question of a surplus did not come up in early agriculture. The ratio between population and food supply remained fairly constant. The population also beyond that engaged in farming was small and industrial concentration in manufacturing was scarcely in existence, the units on the land being self-sustaining in all respects, as in the former days of domestic and individual arts.

The history of agriculture shows clearly that the quite recent tendency has been through improved appliances and methods to foster an increased and dependable surplus beyond the capacity of the population to absorb. The story brings out the succession of the digging stick, the hoe, the plow, the mower, reaper, tractor combination, together with fertilization, improvement of grains, methods of rotation, intensive cultivation on the land, and the use of fire, the ax, the drag, harrow, etc., all contributing to a total surplus. Incidentally, also, these in the improved state bring about the feeding of increasing population and an inevitable surplus. It will be seen that the major items of this development derive from agencies outside agriculture due to the acceleration of what some genius of characterization called economic man.

The object of modern agriculture is a surplus of production. Upon this, as has been suggested, is based civilization and its organizations and industries generally. But the surplus may be looked upon as a result of scientific and mechanical aids coupled with abundant acreage for expansion such as was furnished by the discovery of the New World and extensions of populations in eastern Europe and Asia.

It may be asserted that the first appearance of a surplus that could be handled on commodity terms was in America. It was not the storage of full years in anticipation of lean years, but part and parcel of the vast complex of modern civilization which has means of penetrating to the furthermost corners of the earth carrying finished and raw materials.

Development of Industrial Organization of Agriculture

The development of the modern industrial organization of agriculture as suggested is part of a long chain of gradually unfolding events. It is evident that agriculture is breaking out of the shell which has bound it for several thousand years. The long course of advance shows that agriculture was first merely a family or group asset, then successively a local asset, national asset and finally an international asset.

The latter stage, the outgrowth of a complex of material expansions in which transportation takes a prominent place, presents obvious benefits to mankind. Intercommunication, which is aiding in the effort to establish a central board of information on crop probabilities and the existence of or lack of surplus in various countries, is destined eventually to help the farmer. Famine, which perennially dislocated the affairs of nations by the concentration of human misery, passes over the nations who are in touch with the new age.

Tendency to Overproduction

While a surplus is commendable as showing the difference between good farming and poor farming, overproduction may be regarded as a failure in another direction. The tendency of modern skilled and aided farming is overproduction. All the myriad efforts of science and promotion are bent on production of a surplus, meaning overproduction, which when not fitted to population demands is a clog on economic adjustment. Cheap labor and poor farming is counterbalanced by improved machinery and scientific farming, and the result is overproduction. What should seem desirable is the reverse, for it hits back finally to the unit, stable from the beginning, that is, the family.

The contributions of science to agriculture are numerous and important. For the first time in history has the subject been examined in a methodical manner and correlated with most of the branches of science. That overproduction is perhaps one of the results is not to the disparagement of science; problems like this are in the field of science applied to government policy.

Some of the fundamental contributions of science are insect and disease control, increase of practical knowledge in animal husbandry, soil analysis and scientific fertilization offsetting the "mining" of soil, and other important items. Yet to come may be predicted the extension of the regulated increase in plant and animal variation and weather prediction by the variation of solar radiation. It must be considered also that at the present rate at which chemical science is growing, the food supply may be put on a new basis defying former prediction of overpopulation and famine. Chemical advances point to the lines of utilization of raw materials for the manufacture of food. If accomplished as anticipated, there would be a revolution of the business of farming.

In view of modern discoveries of the essential rôle played by vitamins in the metabolism of foods, it is likely that new deductions may be made on the decay of nations, using as a basis the presence or absence of these substances in the diets which they have preferred or that nature has forced upon them. Probably in the future the advance of chemical sci-

ence will reduce the present apparent necessity of raising enormous crops of small vitamin content. This would allow the farmer to concentrate on limited, more valuable crops, saving labor and giving him more leisure. It is possible that in the review of the development of agriculture coupled as it is with the development of mankind some ideas may be found of use in the present search for aid to the farmer.

Agriculture became a business by the agencies of general progress before the world recognized that there had grown up an industry cognate with the great mechanical industries. Mechanical industries, of course, grew up against the background of farming. This phenomenon was long unperceived, and only recently have men familiar with social changes begun to attempt its regulation.

Stimulative and Corrective Agencies

There is no intention to propose remedies here or to do more than to suggest lines of approach to the subject. There is in the United States at least talent to select the crucial ideas and ability to find the means to carry out reforms in agriculture. Vastness should be no bar to organizations of relief measures, but custom and tradition are.

The psychology of the farmer is the outgrowth of millenniums of struggle, and on account of it he may be described as showing traces of the individualistic and static life he has led in the past. This life we now see as disturbed by the infinitude of currents of modern progress, singling out especially education.

Dissatisfaction is not now with the inadequate returns and opportunities, as under more or less severe despotisms in ancient Egypt and Mesopotamia, but in the complex economic conditions that to-day seem to leave the farmer out of the picture. To line the farmer up with these conditions there are suggestions of organization in great units which have been carried out in areas never taken up by the small farmer.

The difficulty of this project is its application in areas covered by small farms on which the time-honored independence of action is practised. In it also are seen the return to the communal and feudal systems highly difficult as a project even under the copartnership in government of the present time. In any attempt of this sort the small farm unit must be satisfied to enter the scheme as an employee of the industry. Perhaps this eventually will become practicable.

This scheme would require a census of farm products in demand and the supply in order to get a proper correlation. This infers a control of acreage put in crops, which so far no one sees as workable. It also suggests a concentration of effort on the best land for certain crops, thus getting the diversity of required products on the best locales, throwing unuseful land into forests, etc. It is likely that in the future farming may be concentrated on the products of vitamin efficient foods, thus reducing substantially the burdens of needless production.

It will be seen that the matters advanced here look forward to a more rosy future, but the immediate practical aid awaits the earnest efforts of enlightened statecraft.

WHAT IS EVOLUTION?

By GEORGE J. DUDYCHA

RIPON COLLEGE

It has been said that the history of the world is the history of ideas. Like controlling forces in the ancient world were the Greek ideas of fate, justice, courage, beauty and the *Logos* idea. Similarly, in the middle ages the ideas of obedience, faith and love were influential in determining not merely the institutions of the church and the daily life of the people, but the course of history itself. In our own Anglo-Saxon world we may find illustrations in such ideas as liberty, equality, opportunity, efficiency and democracy.

In the nineteenth century the idea of *evolution* first took definite form, and its influence in the thought of that time and in the first decades of the present century was unbounded. Evolution has given us a new conception of the world, startling in its comprehensiveness, applying to animal species, to terrestrial and celestial changes, to language, to human institutions, even to the mind and to our moral laws. It has given us a new method, the genetic method, revolutionizing our ways of approach to science. It has added new charm to the study of plants and animals and a new wonder to the study of the human body.

Incidentally the evolution idea of the nineteenth century affected human thought and institutions in another way. It came into conflict with the church in respect to the origin of man. Violent controversies arose in the last centuries respecting the origin of man and the origin of mind and morals as a result of the introduction of the evolution idea; and in the most recent years these controversies have broken out afresh, disturbing the progress of science and introducing bitterness into the councils of religion.

Hence we see the importance of understanding just what evolution is. A critical analysis of any of the great, influential ideas of history would be useful. Particularly timely is an analysis of the idea of evolution. In the following discussion the primary aim will be to find out what evolution means. It is still too early in the history of the twentieth century to attempt any final analysis of this concept. In this paper I shall undertake to trace through the various evolutionary philosophies of the nineteenth century and of the first quarter of the present century, with a brief preliminary review of such philosophies in ancient Greece and in modern times previous to the nineteenth century, with a view of finding out what the various writers and scientists have meant by the word evolution.

Evolution is an idea belonging not to any one time, but to all the ages. On the other hand, evolution is often spoken of as belonging only to the last century because it received its greatest development in that period and because it was then first used as a basis for science and philosophy. Great advances were made in science as a result of the evolutionary hypothesis, and philosophical systems were built up around the concept. At the close of the nineteenth century the evolutionary philosophy was triumphant; it was the last word in science and philosophy. No man of genius doubted it. How could he when proofs offered in support of it seemed so logical and self-evident? The concept evolution was *the* scientific hypothesis. It spread rapidly from one science to another until it was the primary method of all the sciences, and was applied to every field of thought. Evolution reigned supreme as a theory, and peo-

ple had so much respect for it that they almost made a god of it. Every explanation of social, religious, inorganic and especially organic phenomena was in terms of this hypothesis, this fact being largely due to the monumental work of Darwin and his contemporaries. Up to the time of the great World War this was the general attitude toward the evolutionary philosophy, but during the post-war period there has been a decided reaction against it. In less critical circles this has taken the form of a violent reaction to which we refer as fundamentalism. In philosophical and scientific circles it has taken the form of a careful inquiry into the causes, manner and meaning of evolution. It is true of most scientific theories that some revision of them is necessary from time to time, especially when they are so vitally connected with so many fields of thought as evolution is.

Libraries have been written about this concept, partly because it has been a source of irritation to religion, but mainly because it is a fundamental hypothesis of science. Many definitions have been formulated, around which whole systems of philosophy have been built. There is a vast amount of literature explaining evolution, offering arguments in support of it and applying it to the various sciences as a method. Again, much has been written attacking the theory—setting forth arguments to disprove it. But, as we search further, we find that very little has been written concerning the concept itself.

Before considering an analysis of the term evolution, it would be well to have in mind the etymology and meaning of the term itself. Evolution comes from the Latin *evolutio*, an unrolling; *e*, out, and *volvere*, to roll, *evolvere* meaning to unfold, unroll, to open and extend, to disentangle. Is this what the various theories and definitions of evolution mean?

The first reference to anything like evolution comes from the Ionian school. Thales, the first of this group, theorized about the origin of all things and named water as the substance from which all things come. Anaximander said that it was not water, but the infinite, an eternal, imperishable substance out of which all things are made and to which all things return. Anaximenes tried to define the substance, which Anaximander described, by calling it air. Thus the only contribution which the Ionians made was the idea that all things come from one substance by some process, but they did not have any notion as to the nature of this process.

Heraclitus was the great exponent of the philosophy of change. He believed that all things are in constant motion, nothing is fixed or static, everything is in a state of ceaseless change. "You can not step twice in the same river, for other and yet other waters are ever flowing on." It was through this philosophy of change that the notion of evolution received its most striking statement at the hands of Heraclitus, "who regarded all nature as a scene of 'becoming' according to a certain law of proportionate exchange termed by him *logos*." He did not have any notion of the transformation process of life or of the evolution of species, but he conceived nature, in his broad view, as involved in ceaseless change, and yet always constituting a uniform whole. The contribution which Heraclitus made to evolution is important because he was the first to introduce this concept of perpetual change. Parmenides, who stoutly opposed the philosophy of change, believed that reality is eternal and immutable, and that all change is inconceivable. Parmenides' opposition is significant because it led his successors to propose an explanation for apparent change. This introduces us to the important hypothesis by which change is explained as due

to the recombination of a certain number of fixed and so-called "elementary" substances, namely, four in the case of Empedocles, an infinite or indefinite number of "atoms" in the case of Democritus, about ninety elements in the case of modern science and an indefinite number of electrons or centers of electrical energy in the case of recent physics.

Empedocles has justly been called the father of the evolution idea because he took a great stride in advance of his predecessors. He believed that there were four elements, earth, air, fire and water, which were acted upon by two mythical forces or beings, love and hate —attraction and repulsion. These two forces always act together upon the four underived, unchangeable and indestructible elements, arranging and rearranging them into different combinations by means of a process of endless change. He explained organic evolution as the triumph of love over hate.

We have space only to mention five sparks of truth which may be found in Empedocles' philosophy: first, that change is explained as a recombination of a number of fixed elements; second, that the development of life was a gradual process; third, that plants were evolved before animals; fourth, that imperfect forms were gradually replaced by perfect forms; fifth, that the natural cause of the production of perfect forms was the extinction of the imperfect.[1] Also in his explanation of organic life he made a vague prophecy of the survival of the fittest and of natural selection; but we do not find that he had a well-defined idea of evolution.

Aristotle literally ushers us into a new world of thought, because he towered high above his predecessors and made a lasting impression upon the world by the force of his genius, demonstrating to us the surprising grasp which he had of the whole situation. There are two reasons why we should pause and consider Aristotle, and which make him important in a consideration of the evolution idea. First, his concept of biological evolution. He believed that both the plant and animal kingdoms are graded from simple to complex—imperfect to more perfect—as a result of form being realized in matter. Second, his philosophy of evolution. Aristotle had a philosophy of evolution, which fact we do not find in Darwin, who did not have a world view of cosmic evolution, but simply a theory of the origin of species. This, then, makes Aristotle important, because he had one theory by which he explained all things. Later we shall find that there have been others who have propounded theories of general evolution, such as Spencer, LeConte, Bergson, Morgan and others; but Aristotle was the first and most important.

Aristotle rejected the ideas of both Democritus, who reduced all things to moving, material atoms, and Plato, who assumed ideas separate from matter, and took a middle course, assuming that both matter and form are real. He held that matter had potentiality and form actuality, and that matter realized itself or became actual in form. Form and matter are inseparable; there is no matter without form, and pure form—that which has no matter—is the Prime Mover or God. Thus, for him, development was a gradual, continuous, unitary process in which matter, the potential, realized itself in form, the actual. When applying this idea to nature, he said that there is a complete graduation, and that nature proceeds constantly by gradual transitions from that which is imperfect to that which is perfect, in other words, he believed in the unity of causation in nature. Thus at the very core of his evolution idea was this "internal perfecting tendency," which drives the organism progressively onward to more perfect forms with man as the final product. It is this process

[1] H. F. Osborn, "From the Greeks to Darwin," p. 141.

of realization which we shall find very significant when we come to a consideration of the evolutionary philosophies of the twentieth century.

Lucretius, in his "De Rerum Natura," did not make a great contribution to the philosophy of evolution because he merely summed up the pre-Aristotelian philosophy. Although very mechanistic, it is important in the case of Lucretius to notice what appears to be an almost inadvertent subversion of his boastful mechanistic philosophy by the introduction of an element of spontaneity in the atoms, which he naïvely likens to free will in man.

The first great contributor to the philosophy of evolution after Aristotle was Augustine. Although Augustine was a churchman, he was greatly influenced by the teachings of Aristotle, which he harmonized with his Christian theology, and thus gave us a new concept of development. Putting it in modern terms: "In the beginning God made" the first single cell—germ or seed—in which all things that are found in the world to-day were implicit, and by a process, governed by natural laws with which the Creator endowed this first piece of matter, have become and are becoming explicit. The first cell was the potential universe with all things that are found therein. In this concept we find a trace of Aristotle's forms, and matter realizing itself in a successive series of forms, and the materialistic philosophy of the Greeks, also the Christian concept of the Creator who endowed matter with these natural laws.

There are two things of importance in Augustine's philosophy of evolution with which we should be impressed. First, his idea of an orderly development in the world. This is rather startling, when we remember that it came from a church father, because the church taught "special creation." Augustine, however, conceived the universe as coming from the first seed or germ in an orderly manner, just as the oak grows, "in that order with which we are familiar in nature," from its humble beginning in the acorn to the mighty giant of the forest. Second, and the most important, his notion of the potentiality of the germ. Here we should pause a moment, because Augustine has introduced into the evolution idea a new thought—the potentiality of the germ. Nowhere among the Greeks did we find this idea expressed—the entire universe being implicit in the first germ. This is truly evolution. Augustine thought that development is an unrolling, an unfolding of that which is in the germ, the implicit becoming explicit, and this is the true meaning of the term. Thus Augustine was the *first* to have a concept of evolution which the term clearly and adequately expresses.

The contribution which Thomas Aquinas made to the concept is essentially a reinterpretation of Augustine's idea. He interpreted Augustine as saying: all the potentialities were not given by the Creator in the beginning, but at different times. In the beginning God gave matter a certain potentiality which gradually became actual, later. He added another potentiality which by a gradual process became actual, then He added another and another and so on. At one time matter "received power to produce" grass and trees, and at another time to produce animal life. Development, then, according to Aquinas seems to be an epigenetic process—a gradual building-up of potentialities which were added at different times.

With the advent of the seventeenth century there was a great awakening in science which led to much speculation concerning evolution. There was a whole host of writers who contributed to the evolution idea, the naturalists—Linnaeus, Buffon, Erasmus Darwin; the speculative evolutionists—Millet, Diderot, Oken; the natural philosophers—Bacon, Descartes, Leibnitz, Kant, Schelling, etc., all of whom we must pass over

because we do not find in their writings any definite concept of evolution.

Lamarck's contribution to evolution, made essentially to biological evolution, may be found in the statement of his four laws. In the first law he assumes internal forces—life which was inherent in the first created forms—which are at the basis of all growth and development. The second law, which deals with the "needs" or "wants" of life, as he termed them, is the law which was most severely criticized and misunderstood by his contemporaries. They interpreted his law as meaning that an animal could acquire any organ by simply desiring it. This could not have been farther from the truth. His conception was: a new situation is presented to an organism, the organism must needs react to this changed environment by the use of different organs and parts from those it was in the habit of using, and probably cease to use the organs which it had used in the past. Thus he did not mean mental desires but the satisfaction of physiological wants or "needs." The third law, the law of use and disuse, is the basis for the second law, for if an organ or part is used it tends to develop and become strong, but if it is not exercised it becomes weak and will disappear. The fourth law, which maintains that an organ, organization or function once acquired by an organism is preserved by generation, raises the question of the inheritance of acquired characters. We are all, of course, familiar with Lamarck's classical example of the giraffe and the way in which he supposed it acquired its long neck.

Upon these four laws rests Lamarck's whole concept of evolution. He starts with the assumption: given certain vital, internal forces which cause growth, then, the living, growing organism adapts itself to its environment because of certain needs or desires; these adaptations persist through use or are lost by disuse; and finally, the acquired adaptation or organization is transmitted to new individuals. If his assumptions and these laws are true, and acquired characters are inherited, then the problem of evolution becomes much simpler.

Let us look a little more closely into the meaning of Lamarck's laws and ask first: What did he mean by growth? According to the first law, it is simply the function of internal forces which "increase the volume of every body that possesses it, as well as . . . the size of all the parts of the body up to a limit which it brings about." Thus it is not an unfolding process in which the implicit becomes explicit, as Augustine taught, nor the "perfecting tendency" of Aristotle. He uses growth in the sense of coming to maturity. But growth alone does not account for new species. "Internal forces"—what are these? They are the natural forces of life with which matter is endowed by its Author. He did not analyze these forces; he simply assumed them.

If growth alone does not account for new organs or new species, how, then, do new organs and new species arise? A certain part becomes gradually specialized in performing a certain function; growth causes the part to grow—become larger; use strengthens it, and thus a new organ is gradually formed. This acquired character is transmitted to the next generation, other modifications are passed on by inheritance, some characters being acquired and others lost until the very organization of the species is so changed that it has become a new species. Thus, in the last analysis, his evolution idea depends upon the inheritance of acquired characters and "internal forces" which he did not analyze. It is just these "internal forces" that we would like to know more about.

Between the time of Lamarck and that of Darwin, the evolution idea fell into disrepute because of the strong opposi-

tion against it. There are, however, two names which we must mention, which belong to this period, because of their influence upon Darwin's thinking. These men are, Lyell and his "Principles of Geology," and Malthus with his work "On Population."

Darwin put forth his ideas concerning evolution in his monumental work, "Origin of Species." It is not necessary to review, for the intelligent reader, the details of Darwinism, but a mere mention of its assumptions is sufficient. Darwin made the following assumptions: the extreme fecundity of nature, struggle for existence, variation, heredity and natural selection.

Let us turn to a consideration of these assumptions. The first one is certainly true, nature is extremely prolific. It has been estimated that from a single pair of robins, if none die except from old age, there would be at the end of ten years over two million individuals. Next we come to "struggle for existence." Why is there a struggle for existence? Why do not plants and animals succumb to the adverse conditions of their environment instead of maintaining a struggle? When the great ice sheets came down from the north, they crowded practically the entire plant and animal population of the entire North American continent into a comparatively small area—the southern half of the United States. Certainly crowded conditions existed; competition must have been keen; there must have been a struggle for existence. The question is: was the struggle for existence due to the crowded conditions and the resulting lack of food, or was it due to some other reason? Certainly there must be some internal force or drive which forces plants and animals to do the utmost to preserve their integrity. But why do animals struggle? Is it to satisfy hunger? But why do they seek to satisfy hunger? The reply is that they seek to satisfy the biological needs of their organisms. To satisfy these needs is the very nature of life itself, and it is just here that we unfold the secret. There is a struggle for existence because of the insurgency, activity and spontaneity of life. This being true, the Darwinian idea of struggle for existence is of little interest to use because behind it is the will to live which is life itself.

Darwin merely assumed variation and heredity and did not try to justify or explain these assumptions. He insisted upon the idea that all minute variations, which we to-day know are to a great extent non-heritable, were the principal materials for natural selection to work upon. He believed that all variations are heritable. These chance variations, he thought, occur in all directions and in all structures in a haphazard manner, and only the useful are selected and preserved. Here is the difficulty. How is the first, almost imperceptible variation in a favorable direction of selective value, so as to effect the survival of the individual? What would be the value of the first few hairs of a mammal, that this variation should be of selective value? When we think of some of the complex instincts and adaptations which we find in organisms, we are led to doubt the probability of their arising from slight variations, selected and preserved by natural selection.

Now that we have examined Darwinism and have considered some of the objections to it, we may ask two questions: Is Darwinism, in the truest sense of the term, evolution? Did Darwin have a philosophy of evolution? In one sense we must answer the first question in the negative, in another in the positive. We do not find in Darwin's idea, as we did in Augustine's, any suggestion of an unrolling or unfolding process—that which is implicit becoming explicit. The variation-selection idea certainly does not suggest an unfolding, but rather

a building-up process. Evolution taken in this sense can not be applied to Darwinism. But there is another aspect to the question. If by evolution we mean biological development, the development of all plant and animal species from some common stuff by some process, then Darwinism may be called evolution. Natural selection is a mechanism by which the origin of species may be explained. If there is a struggle for existence due to the very nature of life, if slight chance variations occur which are purely fortuitous and if the forces of heredity are assumed, then it is possible to explain all the complex adaptations of structure and of function in organisms, instinct, intelligence—all by means of natural selection. As to the second question, we are somewhat disappointed. Darwin dealt entirely with the origin of species, and did remarkably well, but he did not expand his theories to include the origin of the universe and all things contained therein. It is in this sense that we must say he did not have a philosophy of evolution. Thus we see that Darwin's concept was not one of unfolding, but one of upbuilding.

While Darwinism is fresh in our mind we must briefly consider Neo-Darwinism. Weismann in his theory of germinal-selection transferred the struggle for existence and selection of Darwin to the germ plasm. He thus gave selection great prominence, but failed to see the great difficulty—the impossibility of verification. Germinal selection is entirely theoretical and can not be subjected to experimentation and verification. Although Weismann did not make any great contribution to the concept of evolution, we must say that he made a sincere attempt to explain the origin of all plant and animal species by a single process.

Another modification of Darwinism may be found in the various orthogenetic theories. Orthogenesis adds to the concept of evolution the idea of direction in evolution. Evolution is not an indefinite, haphazard process, but it is a process by which nature is getting somewhere. Variations occur, but they occur in a linear direction because of what the previous variations have been. If this is true, and evolution is progressing in a definite direction, then it seems almost inevitable to assume a director or guiding force. We can not enter into further discussion of this point here, but will refer to it again later. Let us bear in mind, in passing from orthogenesis, that it is a new idea added to the concept of evolution.

We must turn back in our thought to the time of Darwin, and consider Herbert Spencer, for undoubtedly the reader has been anxiously looking forward to a discussion of his famous formula. Lamarck and Darwin, we found, dealt entirely with biological evolution, but Spencer presented a philosophy of evolution. It is for this reason that we are interested in his famous formula.

Spencer's final statement of his formula stands thus: "Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation." This formula he applied to all phenomena, inorganic, organic and superorganic. Its scope is broad, and nothing escapes it. It is applicable to all things, and thus gives unity to all phenomena.

Whether it be in the development of the earth, in the development of life upon its surface, in the development of society, of government, of manufacture, of commerce, of language, literature, science, art, the same evolution of the simple into the complex, through successive differentiations, holds throughout. From the earliest traceable cosmical changes

down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous is that in which progress essentially consists.[2]

Evolution, for Spencer, was a process of change—a process of integration and differentiation. The elements or materials of this evolutionary process—matter, motion and force—are not ultimate; they are modes of the unknowable, as Spencer calls them. The unknowable is the power, cause or source which is behind and responsible for the evolutionary process. What it is we do not know; but that it is, we are certain. Concerning matter, motion and force—the knowable—Spencer says that matter is derived from motion, motion from force and force from the unknowable. What is the unknowable? I don't know. Thus we are led to agnosticism. Is, then, Spencer's formula hopeless; has it nothing of value to offer us? Let us see.

Whether in Spencer's mind the formula passed for an explanation of the development of all things is difficult to say; but with many of his followers we do know that it passed for a final and perfect explanation. But, does it explain anything? We can hardly say that it does. Spencer uses the terms, integration, concomitant dissipation, indefinite, incoherent homogeneity, etc., very glibly, and the careless thinker might be led to mistake a pleasing statement for an explanation. To say that evolution is the integration of matter and the dissipation of motion does not explain it, but merely states a possible fact. It does not state what causes integration, how matter is integrated or why integration of matter is accompanied by the dissipation of motion. Even if this statement is true, and during the integration of matter and concomitant dissipation of motion, matter does pass from an indefinite incoherent homogeneity to a definite, coherent heterogeneity, what of it? To say that the development of a tadpole into a frog is an integration of matter and concomitant dissipation of motion, during which the tadpole passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity—the frog—does not explain the metamorphosis. It may be true, but we are little wiser than we were before.

The reader may object to this criticism on the ground that the purpose of science is not to explain but to describe. But is Spencer's formula a valid description of evolution? No scientist to-day would answer this question in the affirmative without qualification.

Spencer explained the world as a redistribution of the modes of the unknowable—matter, motion and force—but as soon as we inquire more deeply into this mysterious trio we are referred to the unknowable; and instead of obtaining an explanation we are brought face to face with agnosticism. This form of agnosticism does not appeal to the modern student of philosophy, and hence Spencer's philosophy has lost ground. It is rather disappointing, after studying Spencer, to say that his philosophy does not throw much light upon the concept of evolution. But is there nothing which we have gained from Spencer? Certainly! He contributed two important ideas: first, that evolution is a single total process by means of which we can account for all things; and second, his idea of the unknowable as the force, source or power which is behind the whole process. We shall hear more of these two ideas when we consider more recent philosophies of evolution.

Another definition of evolution which interests us is LeConte's, which we find in his book entitled, "Evolution: Its Nature, Its Evidences, and Its Relation to Religious Thought" (1887). The statement of LeConte's definition is as follows: "Evolution is (1) *continuous progressive change*, (2) *according to*

[2] Morgan, "Spencer's Philosophy of Science."

certain laws (3) and by means of *resident forces.*" LeConte, like Spencer, emphasizes the fact that evolution is a universal process, but he confines his discussion almost entirely to biological development.

What is "continuous progressive change?" LeConte does not give us a satisfactory answer to this question. He tries to describe change by saying that it is like the stages in the individual—germ, egg, embryo, infant and maturity. This is true but it does not tell us what change is. He tries to explain a dynamic concept in static terms. What *progressive* change is, is even less clear. Possibly, what he meant was: evolution is a process of change, each change being an improvement in adaptation to the environment, and resulting in an increase of complexity.

LeConte says that development is according to certain laws. What are these laws? His first law is the law of differentiation—increasing complexity and specialization. His second law is the progress of the whole. What this "whole" is, he does not make clear; but whatever it is it seems to progress in the direction of increasing complexity. Since this seems to be its chief characteristic, the second law does not add anything to the definition, but merely restates the first part of it. The third law is the law of cyclical movement—an unimportant and practically negligible law, as he himself admits. We have left, after this partial sifting of this definition, change, differentiation and "resident forces." This latter element we shall now consider.

LeConte's "resident forces" are *natural* forces and therefore resident or inherent, as all natural forces are inherent. They are God, divine will, or vital force imminent in nature. Thus LeConte assumes God as the resident force which is in nature and which is responsible for the process of change and differentiation. But how this change and differentiation comes about he does not make clear to us.

Let us sum up this definition as we have interpreted it. Evolution is change and differentiation in the direction of greater complexity, by means of a vital force. This is apparently all that we have left that is meaningful. There is nothing expressed in this definition which has not been expressed before; it merely brings some of these thoughts together to form one concept. Change, we have found, goes back as far as Heraclitus; the idea of complexity we found in Lamarck, Darwin and the Neo-Darwinians; differentiation we found in Spencer; and the vital force or God is the Christian concept. Thus as we turn from a consideration of LeConte's definition to creative evolution, let us bear in mind that he summed up some of the ideas concerning evolution which came before his time.

Bergson's philosophy claims to transcend both mechanism and radical finalism, although it does partake of the second to a certain extent. His philosophy regards the world as an organized whole. The harmony, however, is far from perfect; it admits much discord, because each species, each individual even, retains only a certain impetus from the universal vital impulsion. Life, then, is the continuation of one and the same impetus, which is divided into divergent lines of evolution, each line preserving some of the essential causes working along it, and this common psychological element accounting for the fact that we find similar effects at the ends of two different lines of evolution.

He examines the current theories of evolution and maintains that none of them is sufficient to account for the facts. Each represents an aspect of the process, and thus is only partially true; they are only partial views of a reality which transcends them all. Bergson finds in evolution an original impetus of life, passing from one generation to the

next through the developed organisms which bridge the intervals between the generations. This original impetus, Bergson thinks, is sufficient to account for the facts and process of evolution.

Bergson makes his idea of the original impetus clear by the use of a number of illustrations. A vertebrate eye, he contends, should not be thought of as a sum of many parts, but as having a single process or activity—vision. The movement of an arm from point *A* to *B* should not be thought of as an indefinite series of positions, but as a single unitary process. Again, he thinks of the process of development as a subterranean stream which is forcing its way through rock and sand, and whose course is being determined by that which it encounters as well as by the force which it maintains. Or again, he thinks of this process as a rocket flying through space and bursting.

This, in essence, is creative evolution: "Consciousness, or supraconsciousness, is the name for the rocket whose extinguished fragments fall back as matter; consciousness, again, is the name for that which subsists of the rocket itself, passing through the fragments and lighting them up into organisms." A vital impetus passing through matter—the inverse force—and the interplay of these two forces, or the unrolling of this conflict, is evolution. Evolution is not a building-up process because the parts are complete and finished, neither is it progressing according to a plan, else it would be created already. It is a unitary process, simple and indivisible, an action and not states. From this point of view

> life appears in its entirety as an immense wave which, starting from a center, spreads outwards, and which on almost the whole of its circumference is stopped and converted into oscillation; at one single point the obstacle has been forced, the impulsion has passed freely. It is this freedom that the human form registers. . . . As the smallest grain of dust is bound up with our entire solar system, drawn along with it in that undivided movement of descent which is materiality itself, so all organized beings, from the humblest to the highest, from the first origins of life to the time in which we are, and in all places as in all times, do but evidence a single impulsion, the inverse of the movement of matter, and in itself indivisible. All the living hold together, and all yield to the same tremendous push.

In passing from the nineteenth century to the twentieth and to creative evolution, the reader has undoubtedly been struck by the marked differences between the evolutionary ideas and philosophies of the nineteenth century and creative evolution, which we have just considered. The earlier philosophies, with the exception of Spencer, dealt largely with biological evolution and the origin of species—the products of evolution. Bergson is not concerned so much about the origin of species; for him evolution is a process, a creative act, not states or products of evolution, but the process of becoming. He criticizes earlier evolutionists for thinking only in terms of states and not in terms of action. Creative evolution is simple and readily understood when compared to a rocket which is given an initial push, and which push persists throughout the entire movement. The movement is one and indivisible, its unity being essential; it is a single act—a single impulsion resisting matter. The rocket bursts and the sparks fly in different directions representing the divergent lines of evolution; but all is due to the single initial and limited push which makes the entire movement a single act.

Thus as we pass from Bergson's creative evolution to Morgan's emergent evolution let us bear in mind these points: evolution is a unity—a single movement—and an unrolling of the conflict between the original or vital impetus which is realizing itself in matter, and matter which is the inverse action. When we thus understand evolution, we see the forest and not the trees which our intellect insists upon examining.

Morgan says that evolution is the name we give to the "comprehensive plan of sequence in all natural events." Emergent evolution, then, lays stress on the "incoming of the new." The advent of life, the advent of mind and the advent of reflective thought are salient examples of this "incoming of the new" —emergence. The instances of emergence are beyond the ability of man to number, for in the physical world the advent of every new kind of atom and of each new kind of molecule is an example of emergence. This new molecule is more than a rearrangement of pre-existing part—it is something new. The characteristics and qualities of the substances from which it was formed are one, but those of the new molecule are another, and vastly different from those of the elements. It is something absolutely new—a new "form of relatedness."

In brief, emergent evolution may be summed up, in part at least, by quoting the following extracts. Diagrammatically emergent evolution is represented by a pyramid.

> Near its base is a swarm of atoms with a relational structure and the quality we may call atomicity. Above this level, atoms combine to form new units, the distinguishing quality of which is molecularity; higher up, on one line of advance, are, let us say, crystals wherein atoms and molecules are grouped in new relations of which the expression is crystalline form; on another line of advance are organisms with a different kind of natural relation which gives the quality of vitality; yet higher, a new kind of natural relatedness supervenes and to its expression the word "mentality" may, under safeguard from journalistic abuse, be applied.[3]

As a part of his constructive philosophy Morgan takes under acknowledgment three things:

> First, we acknowledge a system of physical events, intrinsically existent, as that which is basally involved in our complete scheme. Secondly, we acknowledge God as the ultimate Source on which emergent evolution is ultimately dependent. . . . Thirdly, we also acknowledge unrestricted correlation of the kind Spinoza postulated under his doctrine of attributes. . . . It is within such an acknowledged frame of reference, with its three-fold relatedness of involution, dependence, and correlation, that world-events take their course "in space and time." But dependence on God is *sub specie aeternitatis*.[4]

In emergent evolution each new emergent is a new form of relatedness supervenient upon the lower levels, involving the lower level, but the lower level is in turn dependent upon the higher. Evolution is a unitary process passing from base to apex of the pyramid—from space-time to deity—the Nisus of which or activity is God.

With this presentation of emergent evolution it is almost needless to reiterate the salient points of the concept; but for the sake of clearness let us restate them briefly. First, we find the idea of change or progress emphasized—a progress from lower to higher levels. But the new is not a rearrangement or mixture of that which previously existed; it is something new with new qualities and characteristics—an emergent. The emergent is a new form of relatedness supervenient on the lower levels. Thus the whole process is one, because the emergent involves the lower levels, and the lower levels are dependent upon the new emergent. The whole process from base to apex is psychical, and thus similar in some respects to Bergson's creative evolution. It is difficult to criticize Morgan's constructive philosophy because he avowedly takes upon acknowledgment the physical world and the Nisus or God through whose activity emergents emerge.

> For better or worse, while I hold that the proper attitude of naturalism is strictly agnostic, therewith I, for one, can not rest content. For better or worse, I acknowledge God as the Nisus through whose activity emergents emerge, and the whole course of emergent evolution is directed. Such is my philosophic creed, supplementary to my scientific policy of interpretation.[5]

[3] Morgan, "Emergent Evolution," p. 35.

[4] *Loc. cit.*, p. 116.

[5] *Loc. cit.*, p. 36.

The last of our twentieth century concepts is found in Patten's "The Grand Strategy of Evolution." Patten believes that evolution is a continuous creative process passing from infinite chaos to infinite perfection, and that "mutual service is the great creative, disciplinary, and saving force of nature. It tends to give community and harmony of action to her constituents, expressing itself in an evolution that inevitably leads toward the fulfilment of their inherent possibilities."

It is evident, since evolution is a single process, that there is some universal, creative process back of evolution and common to all phases of evolution —inorganic, organic, mental and social. For Patten, this creative process is "cooperation, or mutual service." This law of cooperation is expressed by the simple fact that when two or more things are brought together into a definite spatio-temporal relation to one another, and act together cooperatively, a new thing appears with new qualities and new cooperative powers of its own which did not previously exist in its constituents. Water formed by the mutual cooperation of oxygen and hydrogen is a new creation with new qualities and possibilities for world service. The single cell is a system of cooperating proteids and other agents, and its distinctive attribute is life. Patten introduces another concept which he calls "creative drift." All the acts of nature form one continuous creative process which "flows out of an unlimited past, through the present, into a limitless future." This one great process, though infinitely varied in local expression, maintains one common direction or "drift" which may be expressed by the word progress. If we extend our concept of progress by looking farther and farther into the past, we approach the beginning and see nothing but a futile conflict of chaos, a primordial simplicity, continuity and uniformity. This is complete "freedom" with the absence of cooperation. Looking forward we pass from a beginning in universal conflict, in vastness, sameness and emptiness to creative fulness and clarity of infinite organization and unified cooperative power.

Patten thinks that the services and rightness involved in the creation of any particular thing always present a more or less pyramidal series with the "more general, elemental, and enduring phases of the creative process at the beginning or base, the fluctuating and special, at the end or apex." This pyramid is a graded series passing from isolation, impotence, freedom and chaos to compulsion, stability, power, unity and perfection; it is a broad pyramid of mutual services and constructive rightness.

Patten's concept will perhaps be made a little more clear if we draw a parallel between it and emergent evolution. Morgan calls evolution a process of emergence, and the new thing an emergent. Carbon bisulphate is an emergent—a higher form of relatedness—which involves carbon and sulphur, both of which have characteristics vastly different from the emergent. Patten believes that when elements are brought together a new thing is formed which he calls a product. This product is the result of mutual cooperation of the elements from which it was formed. Water is a new product formed by the mutual cooperation of hydrogen and oxygen. A further similarity is that of the things assumed as the starting-point for a constructive philosophy. Morgan takes under acknowledgment a physical world in time and space, and God as the Nisus of the process. Patten says that we must assume matter and energy, time and space. Thus the difference here does not seem to be one of concepts used, but of particular terms used. A further similarity is in the diagrammatic representation. Morgan employs a pyramid with space-time at its base, and divinity, theoreti-

cally and individual, at its apex. Patten also employs the pyramid with "the more general, elemental and enduring phases of the creative process" at the base and unity at the apex. Both have concepts at the base and apex which are very similar, and within the pyramid there are gradations or levels.

Now that we have examined the various definitions, theories and philosophies of evolution, we come in the end to close quarters with the problem, namely, the concept of evolution itself. Have we arrived at any definite results? Let us see, first, how the matter stands with organic evolution.

Biology was the first science to lay any strong claim to a theory of evolution, hence it is not strange that many have associated evolution only with organic development. When we first turned our attention to the concept of evolution we were immediately told to go to Darwin or to the biologists for our answer. This we have done, and now we ask, What have we gleaned?

What are some of the great outstanding ideas which we have found in organic evolution? The first is probably the common origin of plant and animal species. Common origin is an idea which we traced as far back as the Greeks. Thales claimed that water was the source of all things. Others of the Greeks named earth, or air, or fire, or even such an indefinite concept as "the boundless" as the source of all things. The great host of eighteenth and nineteenth century biologists all started with the common hypothesis of the single cell from which all the complex forms of life developed. Thus, as we have seen, all the theories of organic evolution seem to have this one fact in common—the fact of the common origin of plant and animal species. This is significant. All life has come from one common "stuff" by some process.

If we assume common origin, immediately we assume common descent, and a genetic relationship between the individuals and the species which have descended. All the theories of organic evolution have assumed these things to be true, and the great burden of their proof is to demonstrate these assumptions and the mechanism or process which will account for them. If they have solved this problem, well and good —but have they?

The genetic relationship of species, the common origin of all plant and animal life, the descent of man from some ape-like stock are ideas that are accepted by men of science at the present time. The study of evolution which we have made in this paper confirms rather than weakens the theory of organic evolution. But, strange to say, this is practically all that is known of organic evolution. Text-books on evolution at the present time are largely devoted, first, to the fact of evolution; second, to the evidences of the fact drawn from comparative anatomy, from embryology, from geology, from zoogeography and from rudimentary organs, and third, to the various theories, or the manner of evolution, the principal theories being those of Lamarck, Darwin's theory of natural selection, De Vries' mutation theory, and various orthogenetic and idioplasmic theories. Of these, Darwin's theory is the most famous, but at present it is passing more and more under serious criticism.

The plain fact is that at the close of the first quarter of the twentieth century, while the fact of evolution is accepted more and more, neither the cause, manner nor meaning of evolution is known.

At the same time that these biologists accept descent with modification as an actual occurrence in nature, they are most sceptical and reserved about what may be called the driving force behind descent. What is there in nature that has kept in motion this incredible capacity to produce new species? How is it that from age to age large and ever larger floods of new forms have burst forth? To this question no biologist has a clear and unequivocal answer.[6]

[6] Parker, "What Evolution Is," pp. 62–63.

Again we may quote from Bateson's "Problems of Genetics."

> The many converging lines of evidence point so clearly to the central fact of the origin of forms of life by an evolutionary process that we are compelled to accept this deduction, but as to most all the essential features, whether of cause or of mode, by which specific diversity has become what we perceive it to be, we have to confess an ignorance nearly total.[7]

Osborn in "The Origin and Evolution of Life" says:

> In contrast to the unity of opinion on the law of evolution is the wide diversity of opinion on the *causes* of evolution. In fact, the causes of the evolution of life are as mysterious as the law of evolution is certain.[8]

We could make many more similar quotations from prominent present-day biologists and zoologists, but the authority of these three is sufficient to substantiate our statement.

Because of this fact—that little is known as to the causes, manner or meaning of evolution—the fundamentalist controversy has arisen. Because evolutionists admit their lack of knowledge of the causes, the fundamentalists go a step further and deny the *fact* of evolution. No one would deny the fact that the sap rises in the trees in the spring time, and yet we do not know the causes which are responsible for this phenomenon.

As the scientist and the philosopher usually look for a cause, so we ask, What is the cause of species formation? If we assume that natural selection is the mechanism of species formation, then the question arises, What makes the mechanism go? This question the theories of biological evolution do not answer. None of them assumes any force which is the "push" of the mechanism. This is particularly true of Darwinism. An apparent exception may be seen in the various orthogenetic theories, such as that of Eimer and of the other orthogeneticists, which are very interesting but which merely present a mystic factor that is not enlarged upon. Indications such as these do point in the direction of a philosophy of evolution.

Lastly, we may say that the terms used by the last century biologists are too narrow. They talked of variation, selection and heredity, which concepts can not be employed in general evolution. The development of life—species formation—is only a small part of evolution. Thus the concepts employed by Darwin, Spencer and the others are wholely inadequate when we deal with inorganic, stellar, social evolution, or the evolution of the mind. The process of development is one process and we must use such concepts as will be adequate in all phases of this process.

Thus we have found that many theories of organic evolution have been offered; but still the origin of species remains unknown and the manner of species formation doubtful. Darwin presented an elaborate and most interesting theory which held sway for over half a century; but we have found that it is very disappointing, for as an explanation of the process of evolution it leaves so many unanswered questions that we must honestly say that at the present time we get little help from theories of organic evolution as to the philosophy of evolution.

Since this is a philosophical inquiry into the nature of the concept evolution, and since we get little or no help from the theories of organic evolution, we must turn with great expectation to the "real" theories of evolution, or the philosophies of evolution. What are the philosophies of evolution which we have examined, and what light do they throw upon the concept?

The first evolutionary philosophy which we met was Aristotle's. For him all life, yes, all things, are in a process of becoming. The potential—matter—is being realized in the actual—form or

[7] P. 248.
[8] Pp. viii–x.

idea. There is no matter without form, and pure form—that which has no matter—is the prime mover or God. This process of realization of the potential in the actual goes from simple to complex with pure form at the end, or shall we say apex? H. W. B. Joseph, in his recent Herbert Spencer lecture, explicitly states that he believes that this Aristotelian concept is the true concept of evolution. He says:

> There is no process of development unless what develops is all the time that which comes to be; and again, there is no process of development unless it is not in the same way so in the earlier and later phases. This is . . . the old account, put forward by Aristotle in the antithesis of the potential and the actual.[9]

Now let us consider the significance of Aristotle's concept of becoming and its similarity to more recent philosophies. Aristotle said that matter is realized in form, thus he assumed matter and form or idea or God, the latter being the prime mover. In the twentieth century philosophies, we find assumptions similar to those of Aristotle's. Bergson assumes matter and mind. Morgan acknowledges matter and God who is the Nisus of the process. Patten makes similar assumptions. Thus the striking fact is that most of the outstanding philosophies of evolution have the same assumptions under different, yet similar, nomenclatures. But the similarity does not end with the assumptions; there is further agreement. Aristotle said that it is a process of becoming—of realization. For Bergson it is a process in which mind is realizing itself in matter. For Morgan it is a process of relatedness due to the Nisus—God—who works through all. Thus we see that not only the materials of the process, but the process itself, is the same in all these systems. The process is the same in every case, but the imagery used in elucidating it is different. Thus it may be that our particular type of imagery has given rise to many difficulties and has been a handicap in our understanding of the process of evolution as it really is. This is merely a suggestion in which there may be hidden considerable truth.

But, be it carefully observed, the philosophy of Aristotle is a philosophy of development rather than a theory of evolution. The process from the potential to the actual is a phrase capable of different interpretations. It might be understood to claim that Aristotle's concept of development is without points of comparison, or it is quite probable that he could have chosen some other phrase which would have expressed his meaning better than the one he did choose. Since the prime mover is a creative and developmental force, attracting rather than compelling, this system appears to be what we should call a theory of creative evolution.

An elaborate and captivating philosophy of evolution is that of Spencer. His famous formula held sway in the realm of thought for a long time, but now it is receding into the background. Why? Because it has not thrown light upon the concept of evolution. People to-day are seeking for an adequate concept of evolution, and as Professor Urban says, "Spencer's formula has proved very disappointing in this respect, and thus it must be laid aside for other and more fruitful suggestions."

Evolution, we have seen, means unrolling or unfolding—the implicit becoming explicit. This is exactly what Augustine believed development was—an unrolling or unfolding with the implicit becoming explicit. Thus Augustine's philosophy is true to the term. But in our study of more recent philosophies of evolution we have found that evolution is not an unrolling but a building-up process, in which something new is constantly added. Thus in the recent systems we find great emphasis

[9] "The Concept of Evolution," p. 14.

placed upon the new and upon creation. The molecule is something new, the crystal is something new, life is a new attribute, mind is a new quality. The new was not implicit becoming explicit; it is a creation, an emergent. The new Ford car was not implicit in the chariots of the Pharaohs; it is the result of a building-up process, each addition being a new creation. The cinema was not implied in any of the ancient civilizations; it is a distinctly new factor in our modern social life. Thus it seems that the term "epigenesis" would be better than evolution since the process is one of up-building. True, but associations have grown up about this term in biology which would make it undesirable. Also it is a forbidding, harsh-sounding word which makes it unpopular. Are there other possibilities? Is there not some other term which would better describe the process? If the meaning of evolution is that it is a creative process, as we believe it is, in which something new appears at every step, then evolution is a process not of unrolling, but of up-building, and every change is a transformation. Thus the French word *transformisme* is a much happier term than the English *evolution*, or the German *Entwickelung*.

Again we may call it organization, for we have seen that the new does not come as a process of unrolling or by a mere addition process, but as the result of organization. This term seems to be better than the old term evolution, but even it is not descriptive of nature's efforts. If we employ this new term organization, we are led to assume some organizing force, a life force, *élan vital*, or a creative God. We have seen that all the recent philosophies of evolution assume or take under acknowledgment some such force. It is on these "formative forces," forces that are creative, cumulative and synthetic, that our interest is centered.

Thus we have come to believe that the problems of evolution are metaphysical. We are at an end of biological philosophies. "The doctrine of emergent evolution and of metaphysical levels means the break-down of naturalistic evolution."[10] "Thought," says Urban, "is in the position either of abandoning the concept of evolution as in any sense a world concept or else making life the ultimate concept." What, then, is the outcome? Just this, that we must first unthink all our nineteenth century ideas and approach the problem anew. We have found that evolution is not an unrolling or unfolding process—the implicit becoming explicit—as the term would indicate, and as we thought; but it is a process of building up, a process of emergence, or a process of creation which we may call, as Dr. Patrick has suggested, creative effort.

[10] Urban: "Progress in Philosophy in the Last Quarter Century," *Philosophical Review*, March, 1926, Vol. 35, No. 2.

REMINISCENCES OF AN AMATEUR BOTANIST

By Professor FREDERIC T. BIOLETTI
UNIVERSITY OF CALIFORNIA

THESE reminiscences of botanical adventures will perhaps be considered trivial, even frivolous, by serious readers. An account of them might more appropriately be called confessions and they may have some value as a warning to the heedless.

When I took up my botanical studies, if they can be described by such a dignified term, Professor Edward Lee Greene occupied the chair of botany at the University of California. Among his students at that time were Willis Jepson, V. K. Chesnut, Walter Blasdale and several others whose names have become well known as botanists and collectors.

My first confession is that I took up the study of botany without any particular consideration and continued it without any serious purpose. The occasion of my commencing was probably the fact that my college chum, Chas. A. Michener, had enrolled in Professor Greene's courses, probably to find an outlet for a fertile imagination and a large amount of spare time, neither of which was sufficiently occupied by his prescribed courses. Michener had the remarkable and useful faculty of passing a first section examination in any subject without previous study.

Botany in fact was not a study for us but a sport. We used it not as a means of obtaining credits in prescribed science but as a substitute for football games, track events, writing poems for the *Occident* and similar campus activities. We belonged to none of the recognized schools of botany. We were not physiological nor cytological nor ecological botanists, hardly even taxonomic or systematic botanists. We belonged perhaps to the romantic school of botany. We used the field of botany not as a laboratory but as a play-ground. Our heroes were not DeBary nor Strasburger nor Zimmerman, not even Prantl and Engler, but Theophrastus, Rafinesque and Edward Lee Greene.

The idea of utility in botany was abhorrent to us. If a plant had a known cultural value we despised it. Any plant which attracted the attention of a farmer or of a gardener was characterized by the contemptuous epithet of "vegetable" and we refused even to learn its name.

We spent the first weeks of our first course in learning the technical terms of the game. We were taught by Professor Greene that to speak of "a plant with roundish leaves that grows in the woods" was indefinite. To describe a leaf as peltate, with repand margins, fugacious stipules and tomentose indument was both definite and impressive.

We dabbled later a little in plant physiology and cytology with Professor Osterhout, but these activities were not botany as we understood it.

Later we were introduced to another series of terms by means of which we were to arrange plants in orderly armies, corps, battalions, regiments and companies. We learned the insignia of the armies of the Exogens and of the Endogens, the dress and accoutrements of the *Chloripetalae*, the *Sympetalae* and the *Apetalae*. We learned the position and relation of the *Graminae*, the *Leguminosae* and the *Rosaceae*. We learned shibboleths which enabled us to distinguish a papaver from a crucifer and a labiate from a scrophularid.

At this point we commenced the real business or sport of botany. We were instructed in the art and mystery of collecting. We were shown that the successful collector did most of his work on his hands and knees. We learned that a rest of fifteen minutes on a grassy knoll or the edge of a swamp was often more fruitful in discoveries than a hurried walk of half a day. We were taught that a perfect specimen consisted of a whole plant, including fruit, flower and root.

In our striving for perfection this ideal turned our attention to the smaller forms of the higher plants. With the specifications, it seemed impracticable to prepare perfect specimens of a sequoia or of an *Echinocystis megarhiza*. Later we discovered methods of approximating our ideal even with many shrubs and trees. Some, however, such as most of the conifers, remained permanently outside the field of our endeavors, owing to another limiting rule which confined a specimen to the size of a standard genus cover and required it to be susceptible of filing in our standard cabinets.

We were given certain rules based principally on the structure of the flowers. These flowers we dissected for examination, and interpreted our observations by means of analytical keys. One limitation of this examination was that it should be made with the unaided senses or at most with the aid of a pocket lens. Any character which could be perceived only by means of a compound microscope or of a test tube was of no value. You could not add a laboratory to the pack which a collector was obliged to carry.

The use of the senses was interpreted in a very liberal way. We became expert in detecting families, genera and species by smell and taste. In this, however, our skill never equaled that of Professor Greene, who was enabled to separate the Cichoriaceae from the Compositae and align them with the Lobeliaceae by the facts that the odors of *Lactuca virosa* and of *Rafinesquia* produced nausea in the human species and that Lobelia and Sonchus were eaten with equal relish by the bovine. These facts account for the disdain with which we looked upon the "closet botanist" and his paraphernalia of microscopes and of desiccated and fragmentary type specimens.

Finally, as skill increased, we became independent of rules. By intuition we were able to place a new plant on sight within a few lines or pages of its proper position in "Flora Franciscana." Though there was some loss in accuracy, there was great increase in speed which was of importance in amassing and labeling a large collection. Our ambition at this stage was to possess a herbarium containing all the species of California and most of those of the world.

In determining the exact place of a species new to us, however, we still had to do some humdrum and time-consuming work with analytical keys and descriptions. In desperation we would often take our specimen to Professor Greene and he would usually obligingly furnish us with its name. Sometimes, when he was busy, he would refer us to his favorite and star pupil, now known to all botanists as Professor Jepson.

Professor Greene was inclined sometimes to be mildly sarcastic. Once when I brought him a specimen which had foiled me he remarked, "Why, even Jepson knows that!"

Our method in tracking a species to its lair in the pages of "Flora Franciscana" was, after making a usually successful guess at the genus, to trace it through the species key with occasional reference to the full description. It was essentially a method of determination by elimination. If there were ten species in the key and we satisfied ourselves that

it could not be any of nine we concluded that it must be the tenth.

This method was often successful so long as we confined our collecting to the immediate bay region. On one memorable occasion, however, we were informed by Professor Greene that not only was our specimen not of the species we had chosen, but that it was not any one of the species described in the "Flora." It was, *mirabile dictu*, an addition to the "Flora," a species which had escaped the eagle eye of Professor Greene himself.

Most of the additions made in this way at first were introduced plants and those which we found were much fewer than those found by Professor Greene himself during the same period. We were rather piqued at this and almost suspected him of scattering foreign seeds one year to be found and chronicled as introduced weeds the next.

Our operations, which commenced on the campus, were confined for some time to the hills, plains, cañons, marshes and vacant lots of the immediate vicinity of Berkeley. Its flora was and undoubtedly still is very rich and for many months we rarely failed to add several species to our collections on each trip.

In time, however, we were reduced to the counting of the number of species which we could see in bloom on a trip and to making sets of specimens of any species which we found abundantly in perfect condition for collection. In this way we become very familiar with the species of the Alameda and Contra Costa side of the bay within four or five miles of the shore. We also accumulated a fair collection and a considerable supply of exchange specimens.

To give scope to our ambitions and energy, we were soon obliged to extend our forays. We tackled first the sand hills between San Francisco and the ocean, the hills and valleys, the woods and marshes of the Marin County peninsula and finally pushed our raids as far as Mendocino and Santa Cruz along the coast and to Mount Diablo in the interior.

It was at this time that we first experienced the joy of collecting a new and unrecorded species. This added an excitement and zest to our collecting that changed it from a mere recreation to a serious pursuit. We found that other hunters were engaged in pursuing the same game. We began to look upon them as interlopers and trespassers, especially when we found them invading territories that we had come to consider our own.

In our appropriation of territory our morals and customs were similar to those that prevailed in the division of hunting grounds among the Arapahoes and the Blackfeet. Certain regions we considered our exclusive territory. Other regions we respected as belonging to hunters of friendly tribes. A few inconsiderable regions were held to be common property.

The outer coast ranges and valleys from Mendocino County to Santa Cruz we appropriated unconditionally, with a certain tolerance regarding the San Francisco sand hills and Mount Tamalpais. Contra Costa and Alameda counties we considered common and hardly worth fighting for, the game being practically exhausted. The Sacramento Valley and the Vaca Mountains we respected as the domain of Willis Jepson with whom we were at peace. Certain freak hunters, like Professor Howe, who pursued mosses and hepatics, or Walter Blasdale, whose game was smuts and rusts, were considered harmless and allowed to wander at will. Victor Chesnut we looked upon as an enemy and an outlaw. He had collected a *Ribes* and a *Trifolium* in the Napa-Sonoma Mountains in the heart of our main hunting grounds. If we had known his territory we would have invaded it without

scruple. To capture a beautiful and apparently new *Ribes* in a remote gorge on the slopes of Hood's Peak, to bring it back to camp in triumph and then to find that it had already been branded *Ribes Victoris* was intolerable.

Professor Greene as the Great Chief was of course free from all restrictions. We had too much to gain from his friendship to object to his hunting on our grounds. It was Professor Greene who used the names Michener and Bioletti several times in christening some of our discoveries. For this we were deeply grateful.

It was at this time that the great tragedy of my plant-hunting career occurred. From a distant foray on the San Joaquin River I brought home an inconspicuous plant which Professor Greene pronounced not only a new species but a new genus. He named it and published it as *Biolettia riparia.* Alas! Some meddling investigator examined the specimens and, seeing a chance to scalp the professor, stated that it was an old and introduced plant already named. Professor Greene later acknowledged that the plant was perhaps not a new genus but maintained that it was a new species of so divergent a form that it was doubtful whether it should be retained in the old genus.

Of course I sided with Professor Greene; especially as Michener kindly pointed out that a mistake of this kind made my name ineligible forever as a generic name and spoiled my chance of standing beside the prototypes of *Vancouveria, Zauschneria* and *Eschscholtzia.*

During all this time we were continually adding to our herbarium by collection and exchange. We found that new and rare species were in particular demand. In fact, a single specimen of a rare species often secured us several new names for our herbarium. Some of these species had a very limited range or perhaps only a single locality. We were tempted to try to corner the market. We laid dark plots to collect a large supply of specimens of the rarest and then to exterminate the species. I am glad to be able to say that we never carried out any of these plans.

After about two years of active collecting, our herbarium began to assume the proportions and characteristics of white elephants. I was labeling and arranging mine, receiving and sending off bundles of exchange specimens during every spare moment. Michener had the advantage of possessing a well-trained and accommodating mother and sister, who did much of the work for him. At length we were forced to the conclusion that a man who had to make his living must either give all his time to botany or much less than we were giving. We decided, therefore, to combine our collections, to get rid of all our surplus specimens and to cease exchanging. This enabled me to do a little college work and graduate. We could not give up botany altogether, however, but swallowed our pride and changed from collecting to "closet botany." We spent what time we could spare in studying our collections, the collections of others and the literature of the subject.

It was at this period that we experienced the joy not only of finding a new species but of describing and publishing it. New species were hard to find, but we published several. I am not sure whether other botanists accepted our work—botanists are a jealous tribe—but we had great confidence in it. If my name was ineligible as a genus name there was no limit to the number of specific names it might follow.

We soon found that there were much more prolific ways of having your name attached to species than by finding or describing new ones. There were several schemes.

One was to take an old recognized species and split it up into a number. We found that one ingenious operator had taken the common blackberry of England and divided it up into twenty-five or thirty packets, all but one of which he named and to which he thereby obtained the right to attach his name.

Another scheme was to combine or divide genera. It was evidently possible by this means to bag an unlimited number of species. Professor Greene was very skilful at this game.

A most excellent and fruitful scheme was to take a Linnaean genus and give it a name which it probably had in the Middle Ages. In this way one could appropriate even the common or garden vegetables. This, however, required an amount of learning and research that daunted us. Besides, Otto Kuntze had already made this game scarce.

All these schemes, however, had one great objection. They irritated your fellow botanists. It disturbed their ideas, especially those of the amateurs. It depreciated the value of the stock of knowledge in which they had a painfully acquired vested interest.

Chas. Michener, with his usual ingenuity, contrived a scheme which was free from all the objections to these schemes and at the same time was easy of application and fruitful beyond any of them.

It was similar in principle to the devices by which astronomers are enabled to announce the existence of stars before their actual discovery and by which chemists reveal the qualities of elements and compounds which no man has seen or handled.

Michener based his invention on observed facts of current botanical taxonomy. A genus is a group of plants having certain fundamental characters in common which distinguish them from all other plants. These characters indicate a relationship which it is convenient to recognize by uniting the plants of the group under the same name—the genus name.

In this group are smaller groups, each of which has certain other less fundamental characters by which it is distinguished from all other members of the genus group. These smaller groups are called species and each is given a specific name to which the author is permitted the honor of adding his own.

Michener noted in analyzing the descriptions of specific differences in various floras that the number of characters relied on to distinguish a species were few. While the description might be lengthy and the characters mentioned many, most of them differed from those of a closely related species by variations in degree which overlapped. The essential differences in kind were usually few.

Michener, in order to initiate his scheme, which we were convinced was destined to work a complete revolution in systematic botany, prepared a test manuscript.

"I have here," said Michener, in presenting his manuscript to Professor Greene, "the description of a new species of Burbankia which I would be glad to offer for publication in *Erythea*."

Professor Greene read the description and remarked, "This appears to be a well-marked species. I should like to see the type specimen. Where did you find it?"

"It has not yet been discovered," replied Michener.

"Not discovered! Well, then, there is no such species. How can you describe what doesn't exist?"

"Allow me to explain, Professor Greene. It is really very simple. I have noticed that in your monograph of the genus Burbankia you have described and named two species, *B. concinna* and *B. amoena*, which so far as can be learned from the descriptions differ

only in the shape of the leaflets. In *concinna* the leaflets are linear lanceolate; in *amoena*, linear obcordate. Now my species, *B. decora*, differs from both of these simply by the fact that the leaflets are linear spatulate. It has, therefore, equal standing with the other two."

"Nonsense! Young man, you are too modest. The difference is much greater. Your plant does not exist and therefore has no leaflets at all."

"Your observation, Professor, that it does not exist may or may not be correct but in any case it is not a valid objection.

"In the first place, you may be mistaken. It may exist and only be awaiting a more thorough search of our flora. In the second place, if we examine carefully the fossil flora of the world we will find that few or none of the species described by Linnaeus, Bentham and Hooker, Asa Gray or even by yourself, Professor, existed a few hundred thousand years ago.

"This examination, if done critically, however, will reveal numberless species closely related to those of the present day. Many differ no more from species of the present day than does *Burbankia amoena* from *B. concinna*. An alert and acute botanist in the age of *Sequoias* could easily have foreseen and described one or more of the essential specific differences of *S. gigantea* and *S. sempervirens*, even though these modern species did not then exist or were so rare that they had escaped the notice of the most active collectors of the time. An unusually learned monographer might even have foreseen *Biolettia riparia*. Therefore, we have every reason to believe that in the next hundred thousand or million years evolution. . . ."

"That is enough, Mr. Michener. If you are serious, it is evident that you have a most deplorably false conception of the world and of its origin."

Professor Greene was probably not convinced of the theory of evolution. The manuscript was not accepted.

Thus was an idea of unlimited possibilities stifled and the career of a brilliant taxonomic botanist blighted at its inception.

The idea was perhaps not altogether original with Michener. There is evidence that it had already been conceived and used by Samuel Constantine Rafinesque, who lived in the early part of the last century.

Rafinesque is the author of a large number of works on botany, conchology, paleontology, anthropology, history, viticulture and most other profound subjects. The monumental character of his work is indicated by such titles as: "The American Nations, or Outline of their General History, Ancient and Modern, Including the Whole History of Mankind, etc., etc."; "*Autikon botanikon;* or Botanical Illustrations of 2500 New, Rare or Beautiful Trees, Shrubs and Plants, etc."; "*Neogenyton;* or Indications of Sixty-six New Genera of Plants of North America."

That a man should find and describe such a vast number of genera and species was remarkable. Some considered him insane. Others explained it by his travels and collections in wild regions inhabited only by hostile Indians and where no other botanist had been hardy enough to penetrate. This explanation is rendered probable by the fact that some of Rafinesque's plants have since been discovered and his names accepted. It is hardly possible, however, that so many undiscovered species and genera still exist in the United States.

Michener's explanation is the most plausible. Rafinesque, according to Michener, simply described species and genera which his observations and intuition told him might exist or, if they did not, would undoubtedly be brought

into existence in the orderly processes of evolution. Rafinesque thus not only anticipated Darwin, but was far in advance of even the most modern of the Neo-Darwinians.

Michener was quick to perceive the immense possibilities of Rafinesque's method and often described to me the way in which he proposed to develop it.

Any form of plant is possible, in fact, given unlimited time, all forms are inevitable. Some, however, will require millions or trillions of years to evolve. The pressing and interesting matter is to foretell and describe those which will evolve in a few thousand years or less.

To do this all that is necessary is to determine exactly, by a careful study of geology and paleontology, the general character and direction of evolutionary changes in the various orders, families and genera. With these data and the well-known device of extrapolation, it is perfectly simple to determine in their main outlines the characters of future species, genera and orders. "If this work is carefully and skilfully done," he said, "and on a sufficiently comprehensive scale, the systematic botanist of the future will have no need to dispute about names or priority. All he will have to do is to search for type specimens and place them in the proper pigeonholes, labeled with the correct names which I will have already prepared for them."

How much work and uncertainty would have been saved to the botanical clubs of all times if this great and original ideal had not been demolished by the untimely orthodoxy of Professor Edward Lee Greene!

THE MUSEUM OF SCIENCE AND ITS RELATION TO INDUSTRY

By Dr. F. C. BROWN

DIRECTOR OF THE MUSEUMS OF THE PEACEFUL ARTS, NEW YORK

In any type of museum there is some purpose toward which it is aiming, but quite frequently the service that a museum renders may be more important outside the field of its main endeavor. However, it makes for efficiency if the purpose can be defined and the resources of the institution can be corralled to meet the main purpose.

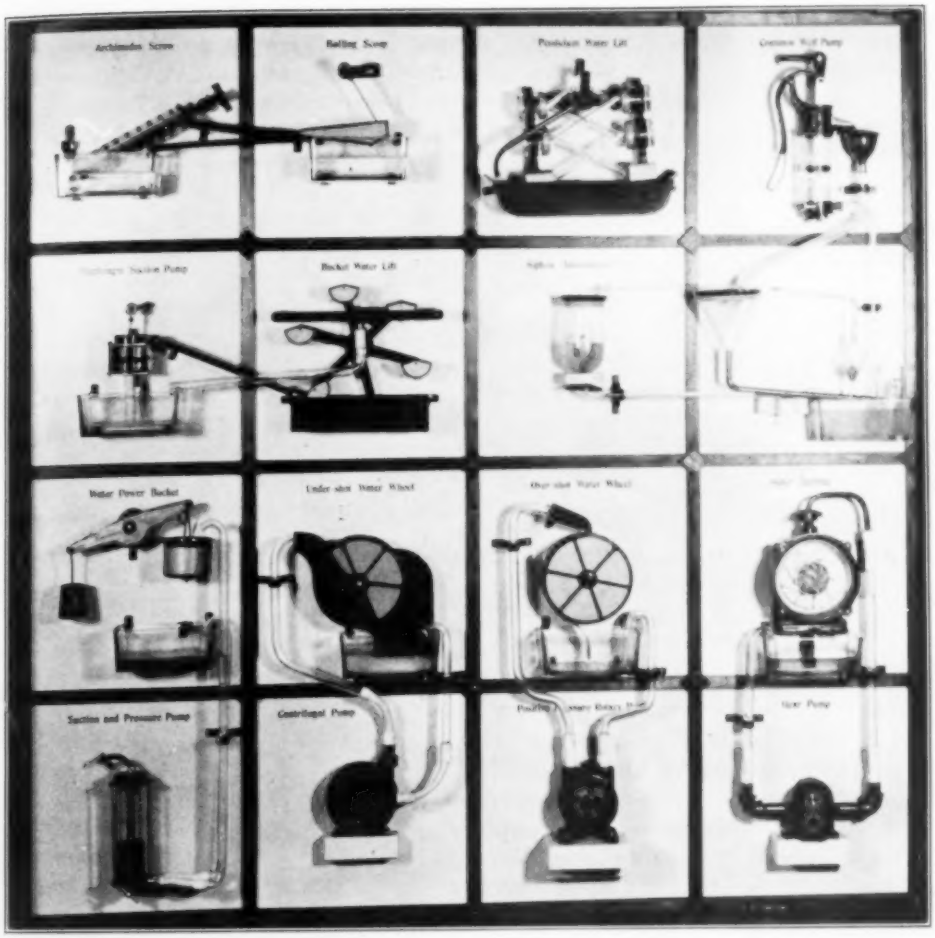
In the old sense a museum was regarded as a depository primarily, and secondly, as a place of research and education. I propose to picture to you the museum of science primarily as an educational institution, but one which makes use of the principles, laws, processes and achievements set forth in their historical relation, and if this picture is well presented, it should be clear that the museum is, in a way, the warp and woof of industry.

This museum differs fundamentally from our universities, colleges and high schools in that it is freer and more democratic, and quite inadequate for purposes of developing moral and mental qualities which come from regular classroom work with punishment and rewards of certificates and diplomas for excellence. I do not anticipate that the museum will give a course in calculus or geometry, or that it will even teach the multiplication table. It is apparent, therefore, that the museum can never be a substitute for a college education. It can, at its best, only aid the other educational institutions and fill educational gaps in the development of the layman. It follows that the museum as an educational institution must necessarily have exhibits which attract as molasses attracts the fly. The museum director must not only be a man experienced in science and education, but he should also master practical psychology and the art of showmanship second only to Mr. Barnum.

The permanent location of the industrial museum should be near the transportation center, where all the schools of the metropolis can reach it most advantageously and also where the thousands of daily travelers from outside the city may find it easy to utilize an extra hour or an extra day. It is axiomatic that any newsboy or any policeman should be able to direct the stranger to the museum and that a minimum time should be required to reach it, without the fear of going astray. You will quite agree that building an industrial museum worthy of the greatest industrial nation is no small task.

The great purpose of our industrial museum is to interpret our mechanistic age for all classes and professions. Words, however well expressed, can only give a vivid understanding when first-hand experience furnishes a background. This is a huge undertaking, but perhaps not as difficult or complex as that of the Rosenwald Museum, which proposes a social interpretation for the visitor in addition to the technical exposition.

The man who has climbed to the top of a high mountain and viewed the snow-capped peaks beyond is the only one who can know the ecstasy of the mountain view. He who has lost a dear friend is best in position to understand the meaning of such a loss to others. He who has worked twenty-four hours consecutively

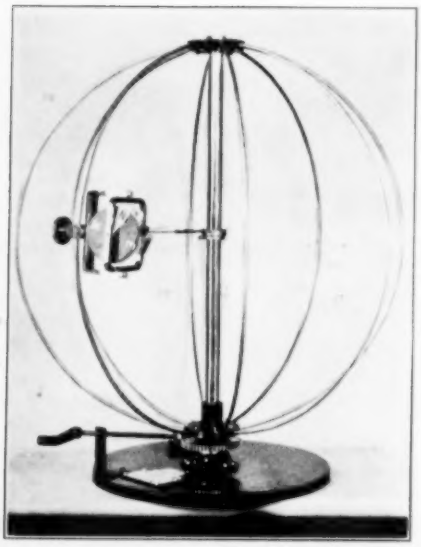


BY PRESSING THE BUTTON

THE VISITOR CAN SET IN OPERATION THE ABOVE SIXTEEN WAYS OF HANDLING FLUIDS. THESE WORK IN PAIRS. FOR EXAMPLE, A BAILING SCOOP FURNISHES WATER FOR ARCHIMEDES SCREW AND THE ARCHIMEDES SCREW RETURNS THE WATER TO THE BAILING SCOOP.

knows best the meaning of work, and he who has been truly hungry for a long period understands hunger pangs. The man who has lived with the stars on the lonely prairie or in the astronomical observatory gets much more understanding of the vastness of space than one who reads any quantity of books without observing the stars or any of the physical phenomena connected therewith. If the book student has only seen the stars at night and has observed the spectra of gases in the laboratory he will have greatly improved his possibility of understanding.

In the vast divergences that our industries have taken with myriads of machines, what hope is there that man can understand to-day and to-morrow the meaning of things? Language at its best is so inadequate to convey the ideas where there is lacking the background, even if we had unlimited time to read. Thus the industrial museum comes in to fill the gap, to portray the growth of the industries and the underlying sciences



SELF-DEMONSTRATING MODEL OF THE GYRO COMPASS

THE RUBBER BAND MAY BE USED TO REPRESENT GRAVITY.

for the common understanding of all people.

Before stating the aim of the museum of science as a basis of an educational institution which serves industry at large, I would like to give the philosophic background. You will recall that our ancestors for centuries upon centuries were herdsmen who gazed at the stars by night and wondered. This wonderment led to the development of astronomy, and mathematics was developed early as a handmaid thereto. Thus, astronomy and mathematics should be the background of a museum having to do with the physical sciences and industry. It is the way the race began.

If we study carefully the ancestors of man as the science of astronomy developed, we will get our cue for the basis of deep interest in all lines of the science museum. Regardless of how busy men are, whether in manufacturing, mining, agriculture or business, they yet exhibit a latent interest in the unknown forces of nature, whether in the atom or the stars, that is just as deep-seated and more far-reaching than man's interest in the prizefight, baseball or football. I believe the reason is clear, namely, that just as man for centuries has taken a keen interest in the development of those qualities manifest in the prizefight and baseball, for just so many centuries his mind has been engrossed with the desire to extend its mental horizon, to know what is in the earth and under the earth. Perhaps there is only one greater allurement for man, which is, to see beyond the end of life. I regret that the science museum, so far as I can visualize, never will be competent to open the door to this greatest allurement, but every other

THE VISITOR DRAWS SMOKE INTO THE CHAMBER IN THE MICROSCOPE

BY USE OF THE BULB, AND HE OBSERVES THE MOTION OF THE PARTICLES DUE TO MOLECULAR BOMBARDMENT. THE MOTION IS KNOWN AS THE BROWNIAN MOVEMENT.

A SMALL RADIO SENDING STATION
WHERE ONE CAN PRODUCE VISIBLE STANDING RADIO WAVES.

phase of extending the bounds of the unknown is open to the museum of science, both as a means of alluring the visitor and as a means whereby his attention will be held and his education improved.

It is not only the small boy who eternally demands "why?" and "how?" for the adult also wonders, when he sees a mechanical marvel, how is it operated, and the science museum answers his questions better than any long technical explanation, which, in many cases, would go far over the head of the average questioner. For example, a man in Grand Central Terminal sees the transatlantic plane *Bremen*[1] suspended above New York's first railroad train. As he gazes at this historic plane, many questions naturally run through his mind, particularly if he has the time to daydream. He wonders how one small propeller can carry such a huge object in a non-stop flight across the Atlantic; he wonders how much air speed is attained, and the relationship between the air speed and the lifting power. He may even wonder as to the rising speed of the plane when it was loaded with 8,600 pounds' weight, and its landing speed when its gasoline was nearly exhausted so that it weighed less than 3,000 pounds. He may wonder as to the principle of the instruments that made this air speed known to Colonel Fitzmaurice and Herman Koehl. He is likely to wonder how the aviators knew their altitude, their position in space, and many other similar questions. The visitor can answer many of these questions for himself by operating exhibits in the Museums of the Peaceful Arts. Not only is there a Fairchild aeroplane in which he can sit and see some of the things that happen, but outside the plane there will be individual exhibits which will explain most of the mysterious principles and instruments involved in an aeroplane.

As we all know, about a century ago the science of astronomy in a measure began to give way to the development of the other sciences, so that following after astronomy and mathematics the museum of science should show the elements of the other sciences, and it is common knowledge that out of these sciences has

WITH THIS, THE VISITOR MEASURES THE BURSTING STRENGTH OF SAMPLES OF PAPER

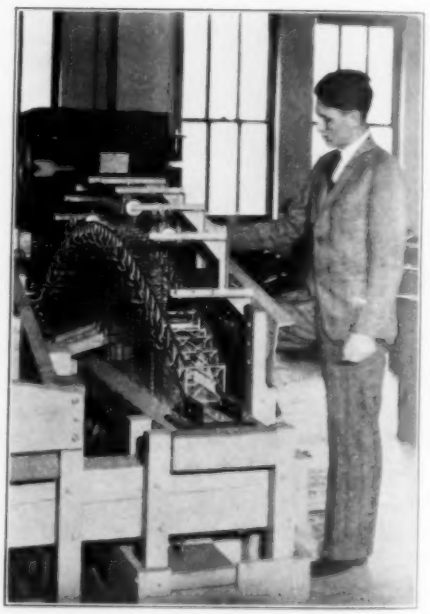
[1] This historic plane will at a later date be a centerpiece in the aviation department of the museum.

VISITOR OBSERVING THE AIR SPEED AND CORRESPONDING LIFT OF A MINIATURE AEROPLANE IN WIND TUNNEL.

grown an industrial age the like of which the world has never before even dreamed. You well know the automobile, the aeroplane, the telephone, the radio, the skyscraper and thousands of industries are made possible in every state to-day as a result of scientific research. Any industry, not excepting agriculture, that does not avail itself of the benefactions conferred by science is in a bad way, and the conclusion is axiomatic that an industrial museum which is both attractive and educational can do its work best if it features well the elements of industry, which are the elements of science.

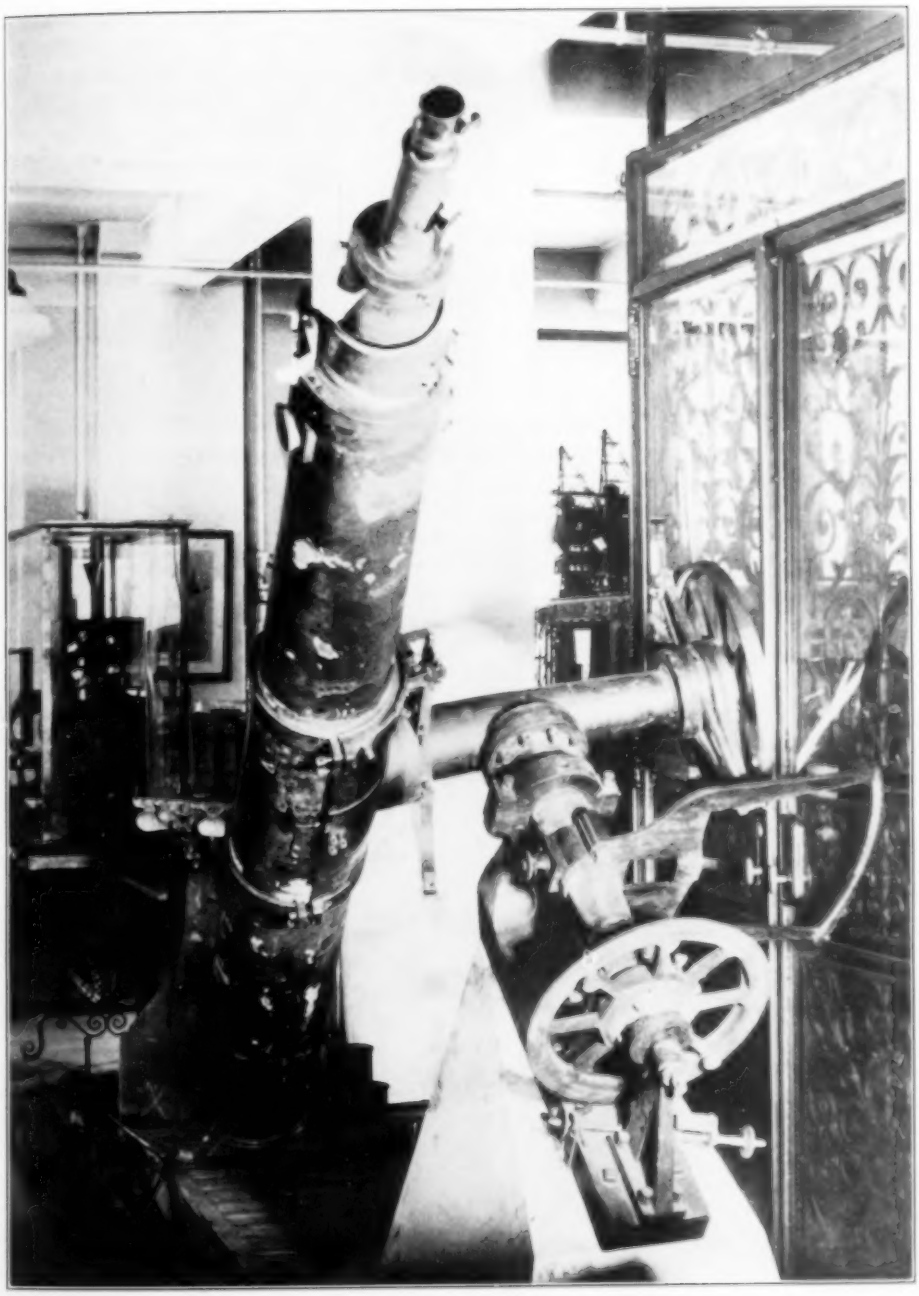
If you wish to know what makes the skyscraper possible, you will have to look farther than the architect, and study the laws of brick and steel and electricity.

There is another basis of attraction which is also quite deep-seated. It is the more sordid one which concerns the economies of our daily living. If the museum of science can train the layman to be more intelligent in his daily activities, so that he can be a more useful citizen or so that he can better supply his own needs, it will cause the public to flock to its doors fully as much as it does to the department store or to the trade show. One needs only go to the radio show or the aviation show to find that there is considerable human interest in the things that concern our daily life. In the museum of science the visitors can learn much concerning food in relation to personal well-being. In Munich I observed recently that the food exhibit had more attracting power than all the other exhibits in chemistry. If the visitor can learn the elementary properties that make an article of dress meritorious, such as qualities of wear, qualities involving cleaning, qualities of color,



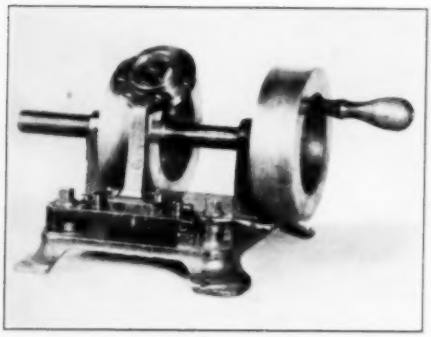
VISITOR OPERATING A MODEL OF THE KILL VAN KULL ARCH

AND OBSERVING THE DEFLECTION OF VARIOUS PARTS OF THE BRIDGE. WHEN COMPLETED, THIS WILL BE THE LONGEST ARCH IN THE WORLD.



AN OLD TELESCOPE

ONE OF THE TWO USED BY RUTHERFURD TO TAKE PHOTOGRAPHS OF THE MOON AND THE CONSTELLATIONS.



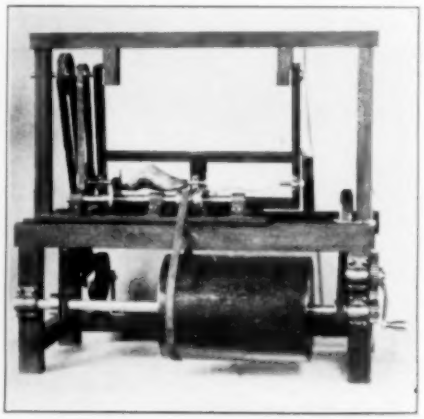
ONE OF EDISON'S EARLY TINFOIL PHONOGRAPHS

such as fastness of color, color harmony and the like, he will be able better to make his pocket-book meet his income and to reduce the waste arising from the manufacture of inferior products.

If the manufacturer and the laymen learn the relative value of bursting strength or tensile strength as applied to hosiery or linen, the waste in manufacture can be very much reduced, and more important than this, the waste in distribution; for I am making the statement without fear of contradiction, that the greatest need of the manufacturer to-day is to have a more educated public or at least a public that is more readily educated.

The manufacturer uses billboards, hand bills, and many objectionable methods of advertising, only because he must, and so on with all the things that people buy to meet their needs. They buy what is placed before them; they do not know, and frequently the manufacturer himself does not know, what is best for the individual. The presentation of museum exhibits which will show our public by the instruments of science and engineering what is best will attract considerable interest.

Then there is a further basis of attraction in the science museum, and that is to employ the instruments of science to determine personal characteristics of the individual. Everybody likes to know little details about himself. If the visitor could measure the elements of his racial characteristics, this would be more popular than the soothsayers of old. However, we can not do this yet, but we can use modern instruments to measure other qualities. I will mention only a few of these. The visitor can measure his weight and height, the color of his hair, the shape of his hair, in comparison with that of different races, he can measure the color of his eyes, and the inter-pupillary distance. He can measure his perfection of hearing, and the limits of his audibility, both for high pitch and low pitch. He can measure the electrical resistance of his skin and the electrical resistance of his body. He can measure his lifting power, his gripping power. He can measure characteristics of his heart beat. He can see the wave form of his voice and measure his lung capacity. He can measure his visual acuity to light of different intensity, he can measure his reaction time to electric shock, his reaction time for seeing and his reaction time to sound. He can measure the temperature of his hand with an automatic electric thermometer, he can measure the radiation



A WORKING MODEL OF THE BLANCHARD LATHE

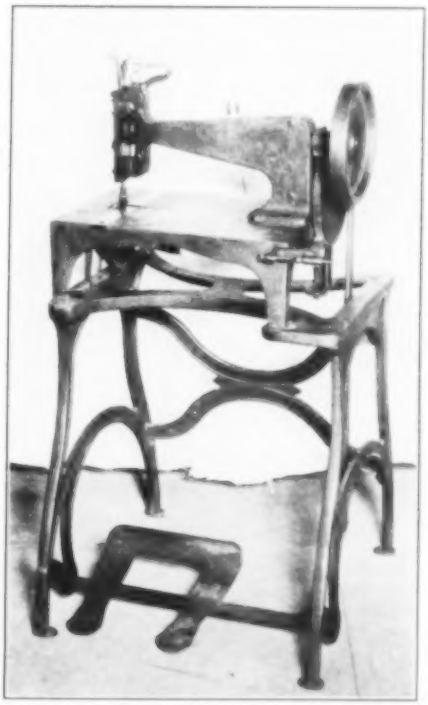
FIRST USED FOR REPRODUCING GUN STOCKS FROM PATTERN.

SEWING MACHINE
USED BY MRS. WILLIAM TAYLOR FROM 1862 TO 1926.

from his face as well as the temperature of his blush.

All of these exhibits, and many more, will not only attract the visitor, but will also give him information which will be a challenge to his imagination and may be useful to him.

You perhaps have been wondering if the museum described here is to be quite devoid of all the relics which in days of yore were the only reason for the existence of a museum. While we are convinced that there is considerable general interest in relics as such, we nevertheless believe that to the average individual relics are of most interest when they are portrayed in connection with their use; that is, an old machine is most fascinating when the visitor can see it operated, or some part of it operated, so that he may see the reason for its existence when it served a useful place in its field. In general, a working and sectioned replica is more useful for our purpose than the priceless relic which can not operate or be touched. However, the museum should have on public display a great many old relics which would serve as centerpieces to exhibits, somewhat as floral decorations are useful in the dining-room. Moreover, there should be many more relics preserved in the archives of the museum, in the same way that books are preserved in the stacks of a library. Such exhibits should be available to the expert or general visitor upon application to the museum office. These, in general, should be housed with regard to the greatest economy of space rather than with regard to the most attractive display. It is my personal opinion that the great national relics in industry, which have priceless value, should in general be housed in the National Museum at Washington. The main purpose of the museum here described is to provide education to the general public as well as to serve as an aid to schools. The general public are treated as laymen alike, and the man of seventy is sup-



AN OLD HOUSE SEWING MACHINE OF 1854
ONE OF THE EARLIEST COMMERCIAL TYPES.

posed to have the same interest in the fundamentals of machines as the boy of seventeen. If, therefore, the museum takes the boy of seventeen as its norm, it will not go far wrong. We should educate our general public not alone because of the general pleasure in obtaining information in an attractive manner, but also for the general good. The banker should know the better and safer uses for the investment of money, the manufacturer should learn of developments in lines akin to his own, in order to improve his own product or the method of its making; the preacher should have an understanding of the mechanisms of his age, in order that he may know better the commonality of his audience. Our civilization is growing faster than any mushroom, and if we are to have a general culture, that culture should consist in its elements of permitting our general public to see the poetry in our modern machines, and that poetry emerges when they see how the velocity of light is measured, how color harmony is produced, how electricity travels, how atoms break up and all those mysterious forces that underlie our age of machines and that furnish a possible basis for all unity in our mechanistic age.

Since the industrial museum is to be an authoritative clearing-house of basic information, useful to all the industries, it would seem to follow automatically that it will be in a degree a research institution in its field, just as the American Museum of Natural History has done research work in its field. However, this will depend largely upon the enthusiasm of the experts in the different departments. Already the Museums of Peaceful Arts has had demands for information that have been the incentive to investigate unknown fields. Experience will doubtless prove that an exposition, as its new and major opportunity, will require a rather complete and exhaustive use of its resources, and that the demands for new information can generally be most economically satisfied by reference to and by cooperation with other existing institutions which have research as the primary function. On the other hand, one of the great services of the museum will be to find and to inspire young men to fill useful places in all the industries.

FITTING THE COLLEGE TO YOUR BOY AND GIRL

By Dr. ALBERT EDWARD WIGGAM
NEW YORK, N. Y.

NEARLY three quarters of a million young men and women are now in the colleges of America, and the following five things represent about the situation they are in and about what is happening to them.

The first fact of the situation is, that if you should see an ox-cart, a covered wagon, a day coach, a Pullman express and an aeroplane coupled together behind one engine, you would have a fairly just picture of the average American college. The engine is the college professor—pulling, tugging and puffing away, trying to pull all this conglomerate assortment of vehicles along at the same speed. And there are three distinct tragedies which result. The first is, the professor is succeeding; the second is, he is proud of it, and the third is, instead of traveling at the aeroplane rate, as the professor fondly imagines, the whole educational train is going at little better than the ox-cart speed.

To apply the foregoing picture: in many colleges from top to bottom, and to some extent in all colleges, the fast boy and girl, the average boy and girl and the slow boy and girl, the motor-minded, the abstract-minded, the artistic, philosophical and mechanical-minded boys and girls, are all given very much the same educational dose.

This type of professor proceeds on the theory that the boy and girl must be made to fit the college, whereas the new educational science says that the college must be made to fit the boy and girl. The students by the old theory are in the main treated as though they were all born equal, notwithstanding that all men are born unequal. It is the business of education to draw out these inequalities and make them more unequal. As one philosopher has said, there is one point on which all men are exactly alike, and that is they are all different. Education should develop these differences, and make them into larger and more effective differences. Yet, the average college professor has not the slightest idea of the magnitude and fixity of these individual differences, and, as a consequence, does not know what his own job really is.

The second fact is that the college is not nearly big enough. It is built for aristocracy, instead of democracy. Only a fraction of 1 per cent. of the American people now get into any institution which could by the utmost generosity be graded as a college, and only a fraction of those who do get in ever get out with a college diploma. The colleges could and should serve at least three to five times that proportion of the American people.

The third fact is that a large number of young men and women are now in college who ought not to be there. Some have ability and lack interest; some have interest and lack ability; some lack both. Many of them could not possibly achieve graduation, and even if, by some miracle, a college course could be forced into their heads, it would not pay either them or the country nearly as big dividends as to have them during these years in business or productive industry. The other side of this fact is that large numbers of young men and women are not in college who ought to be there.

The upshot of it all is that we have no such thing as a national system of selecting and encouraging the young people of the country who could and should go to college.

The fourth fact is that the college is built on what scientists call the "all-or-none principle." It says to your boy or girl, "Four years or nothing. Take our whole educational dose, complete our course, whether it fits you or not, or else go home in disgrace." Partly as a result of this, in many colleges, one half of all the boys and girls who start do go home in disgrace. Not much over half the freshmen ever get through to graduation.

The fifth fact represents the big task which lies ahead in American higher education. It is right here and now, and the college of to-morrow must meet and solve it. That task is educating each individual according to his own endowments and needs, and at the same time keeping up mass production. We must face the fact that the colleges are going to be from two to five times as big as they are now, yet they must at the same time devise systems of instruction and college and university plants which shall save, refine and make effective each boy and girl's personal fineness, uniqueness and peculiarity, a system which shall make each student happy, successful and good at his own private personal level of capacity and desires.

In the future every college that fails to do this will be what many colleges are now, mere factories for grinding out a standardized human product that is all too frequently a misfit in modern life.

In fact, the colleges are to-day grinding out so many misfits; they are struggling vainly to give an academic education to so many students who have no business to be there and putting so many others through courses that actually unfit instead of fit their abilities and temperaments that whenever I see the horde of incoming freshmen, many of whom do not know why they are there and will likely never find out, many others who ought to be there but who are going to be wrongly placed and untrained instead of trained, yet all possessed with a blind faith that somehow the college is going to fill their heads with the knowledge that leads to power —whenever I see this ill-assorted conglomeration of hopeful youth, they call to my mind the young lady who said to her physician, "How soon will I know anything, Doctor, after I come out of the anesthetic?" "Well," replied the doctor, "that's expecting a good deal from an anesthetic." I leave the college professor to make the application.

These impressions of the present status of a great deal of American so-called "higher" education are by no means entirely original with me, but are quite largely the result of several years of friendly acquaintance with Dean Carl E. Seashore, head of the department of psychology and philosophy and dean of the graduate school of the University of Iowa. I have also recently spent two entire days with Dean Seashore, devoted to an intensive discussion concerning his five-year study of American higher education—a study which he has been carrying on as the field representative of the division of education relations of the National Research Council. During these five years, the dean has visited more than one hundred and fifty of the American colleges and universities, and has held prolonged conferences with the faculty, going minutely into problems and methods of educational administration and practice. It is the most extended and important survey of American higher education that has ever been made.

Every parent, professor, philanthropist and taxpayer, as well as every boy and girl who is contemplating the great adventure of going to college, will find the report of this survey, now published

by the University of Iowa under the title, "Living and Learning in College," a mine of information and inspiration. Dean Seashore has been a research and educational leader for nearly a generation. He found something good at this institution, and something good at that. To these findings he has added the experience and originality of his own genius. The result is a constructive program for American higher education of lasting importance.

This survey was first undertaken under the auspices of the National Research Council as "The Gifted Student Project." Experience soon demonstrated that what was good for the gifted student was equally good for the good student—for any student who was willing to work. It has thus become a new national program for all boys and girls who are willing to work and study; for all professors and administrators who are willing to learn something new, or to embody the best practice that has been tried out anywhere. If carried out, it simply means that the American college is going to be made over to fit the student's individual needs, intelligence, interests and character, instead of, as heretofore, trying to make the student fit the college.

Even an educational report can have a soul, and the soul of this report is embodied in the motto which Dean Seashore has developed, and which would do well to be blazoned above the doorway of every school and college. That motto is: *Keep each student busy at his highest natural level of successful achievement in order that he may be happy, useful and good.*

Every word of this motto stands for such a broad principle that we should consider the key words for a moment: "*Each*"—that means each individual and not the mass; "*his*"—his own personal qualities and not those of somebody else; "*highest*"—in many colleges it is a disgrace for a student to do his best; "*natural*"—his natural endowment and not some professor's notions of the endowment he ought to have; "*achievement*"—education must have definite achievement as its aim; "*happy*," "*useful*" and "*good*"—education that does not make happy, useful and good citizens is not worth the paper it is printed on.

As to what this far-reaching formula means, I prefer that Dean Seashore should tell you in his own words. As I think back over our two-day discussion of this whole reformation of American higher education, the dean said to me on this phase of the project:

> This formula cuts at the root of one of the most pernicious theories of all educational systems. That theory is, that where the great Creator has failed to make all human beings equal, it is the business of the school to make them equal.
>
> In order to justify this improvement on the Creator's ideas, the schoolmen have found cover under five arguments, which many of them are still advancing with disastrous persistence. These arguments are, first, that this procedure works towards a democratic ideal; second, that it represents the rights of individuals; third, that it is good for the lowly individual; fourth, that it is justified by results, and fifth, that it is necessary for the operation of educational machinery. Each of these is an alibi, and represents a fundamental error and misconception of fact.
>
> In answer to the first argument, the true democratic ideal is not equal distribution to all, but *equal opportunities in proportion to capacity*. The second argument is just as fallacious; individuals do not have equal rights either in education or anywhere else in life. The genius and the moron do not have equal rights to wealth, social privileges or knowledge. They do have equal rights in proportion to their capacity to create and enjoy these things, and one should be just as insistent upon his rights as the other. The slow student should have his chance, but he should not be allowed to interfere with the fast student's having his chance; and, of course, the reverse is equally true.
>
> But your instructor with a glow of charitable, and what he thinks is democratic, sentiment, advances the third argument. He says, "It is good for the poor student to hear the good

student recite.'' The fact is, it is not good; the humiliation of the poor student in the presence of the good student is often heart-rending. If the facts recited are at the level of the good student, they are totally beyond the comprehension of the poor student, although the latter often assumes an attitude of rapt attention as a defense device to conceal his feeling of inferiority. If the facts are at the level of the poor student, they are of no interest to the good student. The recitation moves too fast for one and too slow for the other; it is, thus, a gross injustice to all.

The fourth argument, that this procedure is justified by results, has a superficial appearance of truth. This is because the instructor does, in a measure, correct what he thinks was the error of the Creator in having failed to make all college students equal. He does succeed in making the gifted student and the slow student so nearly alike that when they come out of college it is difficult to tell the two apart. But it is always because he has dragged the good student down; the poor student can not be raised above his own natural level. As a result, the superior and inferior students come out of college very much alike.

As to the fifth argument, you will see as we proceed that it is not only not necessary to the operation of educational machinery to treat all students alike, but that it clogs the whole educational machine, and results in injustice to all concerned.

It is obvious from the foregoing remarks that this whole new educational program has two great objectives: first, individual attention to each student in order to develop his highest effectiveness, and second, keeping up, indeed constantly increasing, mass production. To achieve these aims Dean Seashore believes that some radical reforms are necessary.

In order to visualize these reforms, let us first ask ourselves how Johnny and Mary ever arrive at college, and what happens to them the day they get there. There has been talk in the home for years about their going to college. Neighbor Jones sent his children, and what is good for Jones's children must be good for Brown's. There are very often other considerations involved, but most students arrive at college through social custom, parental ambition, a prosperous country, accident and the grace of God. A few come from genuine love of learning.

Now let us follow Johnny and Mary through the first week of college. They plunge into a general pell-mell of registrations, entrance examinations and the like, resembling an educational riot, or the mob at a home-coming game. In proportion to the size of the college, from 200 to 3,000 freshmen are herded (there is no other word) into classes, fraternities and dormitories. As to what courses, what instructors and what social groups a student becomes identified with, these are largely matters of chance. Everything is at feverish heat.

From this exhausting process many go home marked as failures. As the year proceeds, from 5 to 50 per cent. of the remainder are sent home. During the sophomore year another group is eliminated; scarcely more than half ever graduate. The students who fail go back home discouraged and disheartened. The whole thing is an orgy of waste in money, energy, hopes and ambitions.

''Now, for all this mêlée and pell-mell,'' said Dean Seashore to me, ''our program provides simple, inexpensive, and, we believe, complete remedies.

''The first remedy is one that we have already demonstrated here in Iowa will work successfully. Instead of letting vast numbers of students graduate from high schools in June and probably waste most of the summer, and then go to college and find out they can't do the work and be forced to go home, we shall select the college students at their homes by a national college qualifying examination. We have tried this in Iowa far enough to know it will work.

''Our program is to administer this college qualifying examination on the same day throughout the entire United States, to every high-school senior and preparatory-school graduate who may

desire to test himself or herself as to capacity and fitness to do college work. This is an enormous step in advance and it will not only prevent the majority of poor students ever leaving home, but will discover a great many young men and women who have not suspected that they had college ability. A small fee will be charged and since the student takes it for his own information, there is no incentive to cheat.

"You see, boys and girls can thus find out whether they can do college work before they have even declared themselves to friends and neighbors. If they fail once they can study up and try it next year again. Thus the boy and girl who now go off with high hopes of parents and teachers, and perhaps with their names and pictures in the local paper, and who are later forced to return home, will be saved this absurd, unnecessary and discouraging experience. We warn them in time.

"This nation-wide drag-net will also be a great eye-opener to the public on the notion that any one can go to college who wants to or whose parents think that he should go. They will wake up to the fact that it makes a difference. It will enormously advertise what is perhaps the most important discovery of modern psychology, namely, the wide differences among people, and emphasize the equally important fact that these differences can not be readily or entirely overcome by some magic system of education.

"Now, this college qualifying examination does not tell us whether the boy that passes will do best as an engineer, linguist, scientist, mechanic, doctor or what. The next two big steps in our program are *freshman week* and the *placement examinations*.

"I first heard of freshman week at the University of Maine, and at once adopted it as part of my program. It applies readily to every college that has more than two hundred freshmen. During the first three days of the week, the older students are not allowed to return except a few upper-classmen who are honored with an invitation in order to aid the faculty in meeting the new students. These three days are devoted by the faculty and honor students to adjusting the incoming students to their new life. The newcomers are shown all the facilities of the campus, libraries, laboratories, health service, opportunities for earning money, assemblies, churches, recreation and the like. Rooms and boarding places are found with some reference to congeniality. The whole aim is to develop a warm, human, sympathetic substitute for the old welcome that was given to our fathers by the college president who received each boy and girl with a fatherly hand-shake and took a personal interest in getting the newcomers under way.

"The last three days of freshman week are devoted to the third great step in making the college over to fit the student. This step is described by the phrase, *placement examinations*. They are given quietly to the new students off by themselves while the old students are coming back and getting located.

"The placement examination consists of two distinct parts. The first half is the regular examination for testing the student's knowledge of each subject. The second half is something entirely new, and is one of the most significant outcomes of experimental psychology. It consists of a large series of tests designed to measure each student's native aptitude for each subject. It is a great advance over the tests of general intelligence.

"Thus, we test, not a boy's knowledge of English, but his fundamental ability to learn English; we test his mechanical ability, his foreign language ability, his chemistry ability, and so on. We now have thirteen subjects in which aptitude

tests have been developed and we are constantly improving them and adding more.

"The outstanding discovery from these tests has been the astonishing amount by which individuals differ in their capacities, and how permanent these differences are. Your natural capacity to learn English or mathematics or mechanics remains relatively unchanged throughout life. For example, we find in the sense of pitch in music, one person may have one hundred times as great capacity as another, and no amount of training greatly alters this difference between these two persons. Training enables each person to use better what he has but it does not greatly increase his original capacity. This we believe is true of all our original capacities.

"Of course, we must distinguish carefully between what a student can do and what he does do. These aptitude tests measure with encouraging success what he can do. As it is now, where the gifted student and the poor student are placed in the same class, the poor student grows disheartened and the gifted student becomes uninterested, and thus neither measures up to his real capacity.

"The next step goes to the heart of this very situation—probably the most important problem in all education. We call this step 'sectioning on the basis of ability.' It is already extensively in force in many grade and high schools. Our plan is to bring it over with the highest refinements of experimental psychology and apply it to the different kinds of college students. We propose to place the students, and we do place them here, in different classes according to their several abilities as indicated by our aptitude tests.

"In order to see how this works, let us recall what has happened to Johnny and Mary by Saturday night of freshman week. Instead of the old exhaustion and bewilderment, they are by that time all congenially located with reference to dormitories and fraternities; they have met all their instructors and many of the older students, and they have a pretty good idea of what living and learning in college really means.

"But, in addition, our placement examinations with their aptitude tests have put in our hands an entirely new educational instrument of the highest value to each student and to his instructors. This instrument consists in the fact that we not only know each student's training, his home and school record, much about his general traits of character and industry, but we also know his aptitude in each of eight or ten subjects in which he has taken tests. I might remark here in passing, that Dr. Frank Shuttleworth, here at the university, has devised a method for securing a student's home and school record, his character traits, home surroundings and the like, which we believe is going to prove of great value in predicting what a student will do with his aptitudes and abilities—how hard he is probably going to work; and we believe that they also predict with considerable success the general trends of character that he will manifest both in college and in later life.

"You see, therefore, that on Saturday night of freshman week, while both the upper-classmen and the newcomers may be holding the grand democratic social event of the season in which they may all meet and clasp hands in good fellowship, there will be on record a comparatively exact and helpful mental profile of each and every student. This profile furnishes every instructor with a fairly accurate, concrete picture of each student's natural level.

"On this basis, we have found it economical to divide the students into at least three levels—high, average and low. This furnishes a fair starting

place for everybody. Of course, the students are informed that these levels are not absolutely fixed, and that students will be permitted to pass up and down as their further achievements warrant.

"Thus, on Monday morning following freshman week, instead of the old exhaustion, misfit and uncertainty, each instructor is in a position to carry out our motto of keeping each student busy at his highest natural level of successful achievement, because, for the first time, in most colleges, he will know fairly well what each student's natural level of successful achievement is. As a further result, the students, as they greet one another on the campus, say to each other, as we know from our experience here they do say, 'I made the ox-cart,' 'I made the covered wagon,' 'I made the day coach,' 'I made the transcontinental express' or 'I made the aeroplane division.'"

At this point I said to Dean Seashore, "Will not all this give the student who lands in the ox-cart a sense of inferiority and failure?"

"No," replied Dean Seashore firmly. "Our experience has been quite the contrary. It affects a poor student just about the way it affects a financially poor man when he finds out he has no money to invest. He simply doesn't have it and adjusts himself to the fact. Is there any reason why he should not do this? It prevents his trying the impossible. It warns him in time. Moreover, the student is told that this is merely a preliminary sorting out, and he is welcome in the aeroplane division as soon as he demonstrates that he can do the work.

"As a matter of fact, the most gratifying result of sectioning on the basis of ability is that the poor student is not humiliated by being compared with the brilliant student. We find that when students are with their equals all up and down the line, their inequalities, inferiorities and superiorities are forgotten. The good student is put on his mettle to compete with his equals and the poor student is working happily with his equals. I absolutely condemn mixing students of high and low ability in the same class. That is one strong reason why the better students have organized in most colleges to keep from doing their best. In many colleges a brilliant student positively has to conceal his brilliancy. If he does not he is against the gentleman's union and is regarded either as 'showing off,' or as a 'scab.' But with this system, a student must play the game and do his best or else be looked down upon as inferior by his own equals. And no healthy boy or girl can stand that. At least, it is a powerful incentive.

"Moreover, the fellow who is often benefited the most is the bright loafer who lands unexpectedly in the ox-cart, and the jolt wakes him up. Let me give you an example: A boy came here from a military school where he had failed three years in the same course in English. He gave as his alibi that he couldn't learn English.

"I said, 'We'll just find out about that.' So I gave him the aptitude test for English ability, and he made a rank of 84 on a scale of 100, on which the average was 50. But when we tested, not his ability to learn English, but what he had learned of English, he ranked 31 on a scale of 100. So we looked him square in the eye, and said, 'You have been loafing for three years; now you have no alibi.' The boy accepted the challenge and got an 'A' on his first paper in English. His mother had encouraged him to believe he had no English ability, and this feeling was going over into other subjects where he was failing. We doubtless saved that boy from a lifelong sense of inferiority.

"Here is another story that goes to

the heart of some of the biggest problems in American education. I think it illustrates a new doctrine in our national life. We tested a boy and found him to rank in the highest 10 per cent. for ability, but his grades showed that he had loafed all through high school. He soon made it evident that he expected to loaf through college. One day he passed an examination in psychology and the instructor gave him a 'C,' but I marked him 'Failed.' His instructor came to me all wrought up, and said it wasn't fair. I said it was fair to mark him 'Failed,' because he had *failed to do his best.* That was a new doctrine. Shall we hold all students to the same standard, or shall we judge the two-, three- and five-talent students each on his own level? Shall we judge a man by his inferiors or by his peers? Nowadays, if a five-talent student gets a passing grade we pass him, and a two-talent student the same. We thus judge all on about the two-talent average level, a level at which the one-talent boy flunks and the five-talent boy loafs.

"To prove this, I told this instructor that any bright boy could get a 'C' in a generalized subject such as psychology or literature. He said, 'Oh, bosh.' I replied, 'Let's try it.' I got a bright boy in engineering and asked him if he had ever studied psychology. He replied he had not. I then gave him the same examination on which the other student in psychology had gotten a 'C,' and this engineering boy got just as good a 'C' as did the one whom I marked 'Failed.' A bright student can get a passing grade in a number of generalized subjects by merely guessing and drawing on his general information.

"You see, as long as we do not divide the students on the basis of their ability, our present standards for passing are set below the level of mediocrity, so that in a subject where general information counts, a student above the mediocrity level can pass without ever having studied at all! Under this absurd procedure there is no use of his coming to college.

"Now the last step, and the cap sheaf of our whole program is the organization of the junior college—a movement which is rapidly sweeping the country. Just think what it is that the college now says to the boys and girls of this country! It is this: 'Take our whole four years or else you are a college failure.' But the new college will say: 'Take the first two years and try yourself out. If by that time you find the last two years are not suited to your needs, tastes, plans, finances, health and abilities, we will graduate you with a college degree which will always be an honorable emblem of successful achievement, the degree of J.C.G.—Junior College Graduate.'

"Some educators have said that a degree of J.C.G. would not be an honor emblem. But my reply is: 'Look at the graduate of the vocational high school to-day. The parents come out and celebrate, they have a big commencement, and all are proud of the boy or girl. Now, if we simply carry that graduate on to two years of college, and give him or her another diploma, the parents will be prouder still.'"

Here I interrupted Dean Seashore with this question, "But, my dear Dean, can not the colleges do away with their first two years, and turn the junior college over to the present high school?"

"By no means," replied the dean vigorously. "The high schools can not become colleges. The life, program and methods of the high school and the true college are as different as night and day. In fact, the general high-school atmosphere throughout the United States to-day is of a comparatively low order as concerns first, their educational standards; second, their methods of study, and third, their social life. What I propose

in these junior colleges is to take the ambitious students out of that atmosphere and set them a new pace, amid new and more stimulating associations.

"As an example, here are three boys, ambitious for a college education. One has the making of a voucher clerk, one an auto mechanic, and the third, a scientist. They first pass the college qualifying examinations at home, and demonstrate that they are college material. All three then start in the junior college. All are given the same course in English, and each will get a course in biology and also one in mathematics during the first year. The auto mechanic also gets one course in the technical aspects of machines and special work on automobile engines. The bookkeeper gets his special work in accounting—something I would give all college students, as I consider accounting far more cultural, as well as useful, than the classics. The scientist gets extra work in the foundation courses of science. The second year goes on much the same, with more stress laid on the particular work which each student will follow in the future.

"At the end of the two years, the bookkeeper and auto mechanic go home with genuine college diplomas, a genuine liberal culture of recognized standing, instead of being marked as 'eliminants' and 'failures.' The beauty of it is that the two J.C.G. men have gone home with a liberal education. They will carry through life the benefits of two years of college atmosphere, of training under the finest pedagogy and with the highest expert organization of their courses of study.

"You should also grasp clearly that instead of having the cafeteria system of allowing the student to select for himself out of a vast number of electives, as most college freshmen do now, the new junior college will provide a suitable number of elective courses or curricula. From these we will assist each freshman with our placement examinations and by every other means in deciding on the curriculum which will best fit his abilities, temperament, economic and spiritual needs.

"These different courses will have as many elements common to all as is advisable, and they will provide against letting the ignorant student decide, as is done now, whether he shall take physics or chemistry, or whether he shall take chemistry first and physics afterward, or *vice versa*, or whether he shall take German, bookkeeping or civics. We shall decide those fundamental things for him. And while the J.C.G. men will go home as college graduates at the end of two years, the scientist and the academically and professionally minded boy will be encouraged to go on to higher fields of educational achievement and responsibility. For we must never forget that ability to achieve and responsibility for achieving go together.

"I have given you an all too brief résumé of the program for the college of to-morrow. I wish I could tell you about what we term our 'project method' of study. By this method, one professor is able to handle a hundred students or more. Yet he is able to give to each far more individual stimulus and instruction than is given by the present recitation system. I think that this also largely meets the common assumption that a boy gets so much more individual attention and personal contact in the small college. In my judgment, the university with thousands of students can be so organized as to give far more attention to each student's individual needs than was ever possible in the small college. I think also that the small colleges can be more effectively organized to meet the individual needs of each student than they are now. In many studies the recitation system will soon be obsolete. We have better and more

individualized methods already in operation. But I trust I have shown you that the college of to-morrow must, and can, discover, orientate and serve the individual boys and girls far more effectively than it is doing now, or ever has done.

"One thing, at least, is certain, that we shall never have a true science of education until each individual in the entire mass is brought to his highest possible development. This may seem a counsel of perfection, but nevertheless it is the goal of applied psychology and experimental education. For, after all, the science of society, the science of living and the science of education have the same end in view; and I know of no better way to express that common objective than in the maxim of our good student project, 'Keep each individual busy at his highest natural level of successful achievement, in order that he may be happy, useful and good.'"

THE BIRTHPLACE OF MAN

By Dr. GEORGE S. DUNCAN
THE AMERICAN UNIVERSITY

I. Mesopotamia

Every one, naturally, has a desire to know the birthplace of man. The earliest known writer having this interest was the author of Genesis 2: 8–14. Here an enclosed park or orchard with many kinds of beautiful fruit trees is described. Such parks were common in Babylonia and Assyria where the owners, their families and friends would find great enjoyment since the climate, in these lands, is at times very hot. The Biblical writer, living in Palestine about 850 B. C., locates the park in a territory called Eden situated in the east. The Hebrew word *Eden* means pleasure, delight, loveliness and charm. Some, however, derive Eden from the Assyrian word, *edinu*, meaning plain steppe and prairie. A large river flows from this territory into the park. As it emerges, it branches into four rivers. One of these is called Pishon, encircling the land of Havilah. Another is named Gihon, compassing the land of Cush. The third river is the Hiddekel, or Tigris, flowing in front of Assyria. The fourth is the Euphrates.

In this brief piece of ancient geography the two rivers, Hiddekel or Tigris and Euphrates, are well known. Assyria is very probably the great empire northeast of Babylonia with its capital at Nineveh. Havilah and Cush are doubtful localities, but the former has usually been regarded as Northern Arabia, and the latter as Ethiopia. The two rivers Pishon and Gihon are unknown. No large river is known which is the common source of the Tigris, Euphrates and the two other rivers, Pishon and Gihon. Indeed the Tigris and Euphrates do not spring from a common source. Their nearest sources, in the Taurus mountains, are at least fifty miles apart. The territory, Eden, is also unknown. This indefinite information about the location of the birthplace of man has set scholars to speculating for well-nigh nineteen centuries. Much time, ingenuity and learning have been spent in the search for the exact location of the park in Eden. By actual count over eighty localities have been given as the site of the first home of mankind. These range all the way from the North Pole to Australia. Only a few of them need be mentioned here since a good many are merely wild guesses resting on no secure scholarly foundations.

Josephus, A. D. 37–100, and many church fathers considered the ocean encircling the earth the source of the four rivers. The Pishon was supposed to be the Ganges and the Gihon the Nile. Havilah was India. Eden would then be somewhere in northeastern India. Calumet, A. D. 1672–1757, Rosenmuller, 1768–1835, Keil, 1807–1888, and some other scholars believed the source river was a region of springs. The Pishon and Gihon were mountain streams. The former may have been the Phasis or Araxes, and the latter the Oxus. Eden was located in Armenia. Calvin, 1509–1564, Huet, 1630–1721, and Bochart, 1599–1667, locate Eden in lower Babylonia. The Pishon and Gihon were regarded as channels by which the united rivers, Euphrates and Tigris, entered the Persian Gulf. Luther, 1483–1546, believed that the great flood so altered the course of the rivers as to make it impossible to locate the park in Eden. Several scholars have resorted to allegory. Philo, 20 B. C.–A. D. 40, considered Eden to be the soul delighting in virtue, while

the four rivers were four specific virtues: prudence, temperance, courage and justice. Origen, A. D. 182–251, believed that Eden was heaven and the rivers wisdom.

In modern times several eminent scholars have attacked the problem. Friedrich Delitzsch, 1850–1922, believed that Eden was the Babylonian plain, and that the park was near Babylon. Pishon and Gihon were canals or ancient riverbeds on the west and east sides of the Euphrates. The Pishon would be the Pallacopas, and the Gihon the Shatt en-Nil. Havilah was part of the desert west of the Euphrates. Cush was a name for Babylonia derived from the Kasshites who ruled there as the third dynasty, 1757–1181 B. C. Paul Haupt, 1858–1926, believed that we must not start with the conceptions of modern geography, but with the quite different ideas of geography which the Biblical writer had in mind. Haupt thinks that the narrative in Genesis should be interpreted somewhat as follows. In northern Mesopotamia there was a large body of water suggested by a dim knowledge of the Black Sea. Here was the park in Eden and the sources of the four rivers. The Euphrates and Tigris flowed southward and ended in marshes. The Pishon, suggested by the Kerkha, starting more to the east, flowed into the Persian Gulf, supposed to be a river. It then turned westward encircling Havilah, Arabia, and finally ended in the Red Sea. The Gihon, suggested by the Karun, starting still further east, flowed at first southward and then westward. It encircled Cush, Ethiopia, and finally ended in the Nile.

These differing views show how difficult it is, from the Biblical data, to get an accurate idea of the location of Eden. The Biblical writer probably had in mind some locality in or near Babylonia, in a region watered by a great river, the supposed source of four rivers, Euphrates, Tigris, Pishon and Gihon. It was natural for him to locate the birthplace of man here. Tradition placed the dispersion of mankind in Babylonia where the tower of Babel was erected, Genesis 11: 8–9. Here was the seat of a very ancient civilization. Abraham, the ancestor of the Hebrews, migrated from Ur in Babylonia, Genesis 11: 31. Present-day Old Testament scholars would probably agree in saying that the Biblical writer had only vague and indefinite ideas of geography east of Palestine. He was a spiritual specialist and not a geographical expert. His geography can not be harmonized with our modern exact knowledge of lands and rivers in the Near East. This is not at all surprising, for even Alexander the Great, 356–323 B. C., supposed that he found the sources of the Nile in the Indus because he saw crocodiles and beans there. Pausanias, in the second century A. D., relates the tradition that "the same Nile is the river Euphrates which was lost in a lake and re-emerged as the Nile in the remote part of Ethiopia." L. E. P. Erith correctly sums up the whole matter thus:

> Speculation as to the site of Eden is futile, as may be seen by the discussion in the standard commentaries of the many localities suggested. All that can be said is that the narrative contains reminiscences of the country between the Euphrates and Tigris, and any fertile spot in Mesopotamia may have furnished the basis of the story of the garden.

In recent years important archeological work has been done in Babylonia at such ancient sites as Nippur, Babylon, Ur and Kish. No human remains or artifacts much older than 4000 B. C. have thus far been found. Probably no scholar any longer believes that the birthplace of man was in Mesopotamia.

II. Africa

Some regard Africa as the original home of mankind. As early as 1871 Charles Darwin, in his "Descent of

Man," wrote: "It is somewhat more probable that our early progenitors lived in the African continent than elsewhere." More recently, G. Elliot Smith in his "Essays on the Evolution of Man," 1924, favors this continent. He says:

> I call attention to these considerations to suggest that the evidence now at our disposal affords some slight justification for the speculation that Africa may have been the area of characterization, or, to use a more homely phrase, the cradle both of the anthropoid apes and of the human family. In any case it is probable that Africa played an important part in the early history of man and his ancestors.

Two discoveries made a few years ago have also revived this view. In 1921 in Rhodesia, the Rhodes man was found. He is more primitive than the Neanderthal man. In 1924 at Taungs, Bechuanaland, fifty feet below the surface an ape was discovered. Professor Raymond Dart, of Johannesburg University, places it in an intermediate position between man and no-man. The two species of anthropoid apes nearest to man, the gorilla and chimpanzee, are found in Africa. The earliest known remains of anthropoid apes have been unearthed in the Fayum in western Egypt.

A. N. Pond and G. L. Collie, recent explorers in the Sahara Desert, favor Africa as the birthplace of man. So also does Dr. Cadle, who has been exploring the Kalahari desert in South Africa where he found pygmies in Stone Age culture who chattered like baboons and who could count only up to three. The Oriental Institute of Chicago University, under the direction of J. H. Breasted, is engaged in studying the Egyptian Stone Age culture on the Nile. Ancient flints show that the valley was occupied by man about 15000 B. C. Here probably civilization began. By 4000 B. C. the art of communicating by picture writing became well developed. Arts flourished and an organized centralized government appeared in the Nile valley.

III. Europe

Europe has been regarded by some as the cradle of mankind. This opinion has been held for two main reasons. Very many skeletal remains of prehistoric man have been found in Europe. The Heidelberg, Piltdown, Neanderthal and Cro-Magnon remains were all discovered on this continent. Then, too, very many artifacts have been unearthed in Europe. These consist of weapons, tools, implements, utensils, pottery, paintings and sculpture. Among the scholars who regard Europe as the birthplace of man is A. Hrdlička, who says: "The cradle of the human race was western and southwestern Europe."

IV. Asia

In recent years numbers of scholars have come to believe that central Asia has the best claim to be the earliest home of mankind. There are ten main reasons for this view. (1) The oldest human remains, the Java man, were found on the island of Java which was once a part of the mainland of Asia. (2) In 1921 in a cave southwest of Peking a premolar and molar tooth were found. These go back to the early Quaternary age. (3) Artifacts, the handiwork of prehistoric man of not later than 25000 B. C., have been found in Mongolia by Roy Chapman Andrews. (4) Sand-drifted ruins of a very great age have been found in Mongolia. These, while not yet explored, are supposed to represent a very ancient civilization. (5) Two species of anthropoids have been discovered in Asia. These are the orangs and gibbons. (6) Remains of Primates, the highest order of mammals, either ancestral or closely related to the living anthropoids have been unearthed on this continent. (7) Most of our domestic animals and cereals have come from Asia. (8) Mongolia is the oldest dry land on the globe. It has been dry twenty million of years, while other parts of the earth have been submerged. (9) The great size of Asia,

with varying life conditions, would be favorable for the development of primitive man. (10) Asia is located centrally to other lands. Migrations going north, south, east and west could easily start from here.

Among the scholars locating the birthplace of man in Asia the following may be mentioned. S. W. Williston, says:[1] "Man was born and attained elemental civilization in Asia because there was the place of all others upon the earth where evolution, in general, of organic life reached its highest development in late Cenozoic times." H. F. Osborn writes:[2] "The unknown ancestors of man probably originated among the forests and food plains of southern Asia and early began to migrate westward into northern Africa and western Europe." J. M. Tyler[3] remarks: "But the climatic conditions of that time lead us to seek his original cradle somewhat further northward than India or even Beluchistan, and nearer to, if not in the great steppe zone of central Asia." E. G. Conklin says:[4] "From his earliest home, probably in the table-lands of Central Asia, successive waves of human migration have flowed forth in all directions." R. S. Lull observes:[5] "That Asia is the birthplace of mankind is seemingly established." J. A. Thomson writes:[6] "The possibility is that the cradle of the human race was in Asia." W. H. Worrell says:[7] "On the whole it appears most likely that man first appeared somewhere in Asia." It is expected that the explorations of Roy Chapman Andrews in Mongolia will confirm the Asiatic origin of man.

[1] *Pop. Science Monthly*, 1910.
[2] "Men of Old Stone Age," 1918.
[3] "New Stone Age in Northern Europe," 1921.
[4] "Direction of Human Evolution," 1921.
[5] "Evolution of Man," 1922.
[6] "Outlines of Science," 1923.
[7] "Races in Ancient Near East," 1927.

THE PEACEFUL PENETRATION OF ATOMISM

By Dr. EDGAR J. WITZEMANN
UNIVERSITY OF WISCONSIN

As the mass of facts and opinions available in the field of science grows at its present enormous rate, it becomes increasingly difficult to exercise that subtle discrimination by which we are often kept in the right path of progress. It becomes increasingly difficult to avoid blind alleys. This is realized by our more mature and successful colleagues, and tempts them to map out the path which must be pursued in the future. Much of this is of the greatest value, while on the other hand some of it comes from fatigued workers whose courage and insight are at a low ebb. In many instances the necessity of taking the suggestion *cum grano salis* is obvious; in others it is not. Moreover, the map supplied is sometimes accompanied by a commentary, stating that certain courses must under no circumstances be entered upon because these lead to chaos. In other words, the straight and narrow path is pointed out with the warning that the other "goes to the devil." In this way the research worker is led to fear heresy and his colleagues to punish him as a heretic if he insists upon pursuing his "evil" ways. Now "going to the devil" in the eyes of friends and colleagues has always been one of the unique privileges of a creative mind, and it would be unkind to minimize the hazards in this respect. However, there are certain heresies of this sort that ought to be discussed from time to time, because the fact that they are merely heresies and not errors is not altogether obvious.

Recently the writer has heard and read a number of warnings against atomism in biological thought. This is alleged to be a line of approach to the problems of life which is bound to fail—any other attack is to be preferred to the chaos that would result from such an approach. In justice to the commentators referred to, it ought to be admitted, in the beginning, that all of them were right when judged from the standpoint of their own view and vision of atomism; and this essay is justified as an attempt to achieve a more adequate conception of atomism, not so much on the basis of what it has been, but upon what it now appears to be.

For our purposes, we may define atomism as a conception that the universe is built up of discrete units. Such a view would be the opposite of that which considers the units in themselves as nothing—the whole is all that there is.

Without attempting to justify either of these views or to elaborate upon the suggested polarity of view-point, let us consider the atomistic conception and its contributions, since this is the approach that we so frequently misunderstand, and is the exceptional, rather than the common view of things.

Just who first adopted the atomistic way of thinking will never be known. We know to a certainty that cultured men have discussed the matter since ancient times. Thus the differences in the nature and qualities of emeralds, pearls and diamonds may well have been a subject of polite conversation in those days. Surely, on some such occasion a prophet ventured the statement that only by taking these gems apart could their true nature and the basis of their differences be determined. No doubt he was laughed out of court, and told that one might as well think that one could determine something of importance about a fine painting or fresco by discovering the nature of the pigments and

the vehicle used in the paint. This view held the field, for the main part, until about one hundred and fifty years ago. By that time the chemist had perfected his tools sufficiently to attack the problems effectively. The story of the solution is well known and need not be reviewed. The atomist has pursued his way until he is now equipped to attack successfully all problems relating to the atomic constitution and nature of things. Moreover, he has taken his atoms, formerly indivisible (by definition), and by subdivision has achieved the potent electron—the electrical atom. In so doing, he has brought his dead atom to "life," to his own astonishment. Then, in order to visualize the relations and behavior of this "living" atom, he has had to borrow concepts and methods from the great field of atomism—namely, astronomy. When these atomic physicists and astronomers get through with the chemist's dead atom, it will be a strange and wonderful "creature."

Now it is a surprising thing that some of our modern prophets wish to caution us against visualizing any possible intermediate realms of atomism developed on scales larger than the inconceivably small astronomical systems of the atomic physicist and smaller than the inconceivably large "atomic" systems of the astronomer. Such an attitude takes no account of the possibility that these two realms are the two ends of "the same stick," and that possibly the path that we are warned against is the obvious one for us to explore. Fortunately, perhaps, the warning comes too late. The atomic "horse" has already been stolen and used with effective power by biologists in several ways.

The whole history of morphology illustrates on the one hand the reluctance of the biologist to have recourse to "atomic" concepts, and on the other the marvelous illumination that has followed their use. Eventually, however, the cell doctrine was achieved by the biologist, and in spite of the disadvantages of seeing so little of his problem at one time he has made enormous progress with it. This progress has been accelerated more and more as the focus has been sharpened and the conceptual magnification increased. For instance, the problem of sexual reproduction is one of atomism. First, we had the microscopic sex elements. The novice shown a giant oak and then a grain of pollen from a blossom might easily find the suggestion ridiculous that such a minute bit of yellow dust could play any significant rôle in the life of a great tree. But biological atomism has gone very much farther. This atom of the oak has been subdivided until the grain of pollen becomes a complex system of smaller units, some of which actually determine the species characters of the future oak-tree.

Bacteriology in its various branches has developed its own atomism. Perhaps the original indivisible atom was in this case the bacillus, but as in the case of the chemical atom this is apparently undergoing subdivision and is breaking down as a limiting concept. We have the filtrable viruses and bacteriophage as possible subdivisions of the bacillus. In fact, the whole trend and the tendency of the recent history of the cell, the biologist's "atom," is in the direction of further subdivision, in which respect its fate is analogous to that of the chemist's atom.

We might elaborate the discussion of atomistic conceptions in biology, but the above is sufficient to indicate the importance and fruitfulness of the view-point in the last fifty or sixty years. Probably these developments are not directly due to chemistry, but surely the workers in these sciences have not failed to obtain encouragement from the success of the chemist in his simpler field and problems. In fact, some of the fundamental advances were made by chemists working

in these fields with their well-tried and proven chemical technique of thought and work.

At just about this point, some one will wish to interject that the use of the term atomism in relation to morphology is, after all, based on analogy. The chemist has isolated his chemical elements, while the elements of the morphologist have never been isolated. In all fairness, we must admit that the geneticists have gone farther in the isolation of their "elements" than any one could have dreamed they would twenty years ago, and that the word "isolation" in this connection is used in a somewhat different sense than that in which it is usually employed by the chemist. The chief objection does not, however, arise in this connection. It actually arises from the fact that there is no known intermediate step between the field of these living biological elements and that of the true chemical elements. Since this is the range in which we pass from the animate to the inanimate, in our usual way of thinking, it constitutes an important step. As we have seen, the biologist started from the consideration of gross units, and is moving toward the fine; the chemist started his attack from the fine, and is moving toward the gross, as in the field of colloid chemistry, and they have not yet gotten close enough to join hands and forces to the best mutual advantage. Where will this union of forces occur, and what problem may it be expected to solve? To answer such a question is perhaps unwise, but if the attempted answer is stimulating, it will have served a useful purpose.

It takes no especially profound insight to see that this union will occur in the field of the chemistry and biology of protoplasm and more specifically largely in the field of proteins, for reasons which may be briefly reviewed.

Under the conditions existing on the earth, carbon and hydrogen form many compounds. If we add oxygen to the pair, the number is enormously increased. If we add a few other elements to the list and consider all known combinations, the organic chemist will show us a series of several hundred thousand, and admits that he has no idea how many more he might obtain. Some of these compounds are proteins, and some of the proteins are water-soluble albumins. Although albumins from various sources appear to be very nearly alike chemically, yet results of biological tests give basis for the belief that perhaps every species of plant and animal has its own specific albumins. The idea of similarity and identity arises only from the use of an inadequate method. The chemist is in this case driven to admit that so far as an eventual understanding of the nature of the species specificity of proteins is concerned, he has made about the same relative degree of progress that the ancients had made when they spoke of their four elements, one of which was "earth." As we know, "earth" has now resolved itself into about ninety individual elements, and we know a great deal about how these are combined to make "earth." Zealous pursuit of the atomistic conception brought us to where we are at present in this field. The same type of attack has, however, so far failed to enable us to solve the protein problem. We know the nature of the chemical elements, of the chemical groups, of the chemical units or building-stones and many other facts about proteins, but all the things that we know tend to make us emphasize their similarities—they are all "earth." The true atomicity of these compounds, if they are to be viewed in this way, therefore involves something that is unknown, or at least is not associated with proteins in our thinking.

That this unknown factor, whatever it is, lies at the very basis of life itself is clear to every one who has thought of it. Along with water, proteins are quanti-

tatively the most important factor in the chemical basis of life. The three main organic components of the cell are proteins, carbohydrates and fats. The carbohydrates are, aside from their elaboration into chemically inert systems for skeletal support in plants, the fuel of the organism, *par excellence*. The true fats are essentially food reserves, and so not primarily concerned. This leaves the proteins as the quantitatively important protoplasmic components which constitute the foundation structure for life, the activities of which are essentially conditioned by water and modified by a host of other components of no quantitative importance, but which qualitatively have a very great importance, the limits of which are at present unknown. May we, therefore, not say that the proteins are the chemical atoms of life, and just as the nature of earths is determined by the chemical elements of which they are composed, so the nature of the organism is determined in some important part by the characters of its proteins. That is, organisms are composed of "atoms" of a higher order than the atoms and simple molecules of the chemist that are usually considered. The chemist's failure to interpret life, therefore, arises from his attempt to use a lower order of atoms and molecules as his units. Such "biochemical atoms" have nothing in common with the chemical atoms when considered in one way, and have everything in common with them when considered in another way.

The idea that there is another world within the range of dimensions under consideration is not new. It is suggested by the arresting title of one of Wo. Ostwald's books, "Die Welt der vernachlässigten Dimensionen." By incorporating the idea of the neglected dimensions, Ostwald tried to drive home the fact that between the realm of molecular dimensions and that of microscopic dimensions there is a whole world of phenomena usually called colloid chemistry. It is in this realm that the preparatory work is being done which will possibly lead to the definition, at least, of the biochemical elements of life, and possibly eventually at some future time to their isolation and synthesis. We are still in the alchemistic stage of this chemistry; our interest is chiefly the transmutation of base metals into gold, *i.e.*, corn into hog fat and pork chops, and the search for the philosopher's stone, *i.e.*, condiments and cosmetics, anesthetics and aniline dyes. When our quest becomes unselfish, we will step out of the alchemistic period into the modern period of this chemistry.

Although we can not define these biochemical elements, we can perhaps see something of how they will appear in general. In atomic chemistry, our atoms may lose or gain one or a few electrons, and in either case, they become chemically active, *i.e.*, alive. Chemical death is persistent retention of just the right number of electrons. When atoms combine, presumably the attractions are satisfied, but if they remain so in all cases, we again have chemical death. When molecules or radicals have more or less than their quota of energy, even momentarily, they become chemically active. Without elaborating this in further detail, it is obvious that every atomic system, on whatever scale it is conceived, will have properties of this sort, and consequently one of the recognition signs of an "atomic system" will be this momentary lability or unsaturation.

This hypothetical discussion may be summarized by saying that even now chemical data are falling into order in such a way as to justify the suggestion that the "biochemical elements" of life will be found in the range of colloidal phenomena, and that if they actually exist they will have a complexity of this order.

Filling out the atomic scale beyond the range of the morphologist's units of cells and on into the higher ranges will not require so much imagination, but rather a fine sense of discrimination. For instance, an individual human being is a social atom. Polarity in the first instance arises with sex. One man and one woman, given suitable affinity, constitute the most stable, self-contained, social molecule. Two of one and one of the other may develop instabilities not manifest in the simple binary unit. In fact, all the characteristic processes of chemistry can be readily represented and elucidated by the use of human relations, including positive and negative as well as primary and secondary catalysis, autocatalysis, etc. These societies are in turn the atoms of larger units. Moreover, it is clear from the biology of insects, and of man especially, that this building up of more and more complex units is an essential part of the evolutionary process. So, just as there is a periodic law of the chemical elements in which similar properties recur in a somewhat different form, associated with a more complex atomic structure, so in nature as a whole there is a comprehensive periodic law, of which that of the chemical elements is perhaps only the initial stage. Similarly, just as the stability of a chemical atom decreases when the complexity of the positive nucleus reaches certain ranges under conditions that we know, so the biochemical elements of various orders reach limiting values. Thus, since surface increases as the square, while volume increases as the cube, and since all cellular supplies and wastes must pass through the surface, the relation of surface to volume will show optima for every range of biological units. Thus, the yeast cell, the sponge, the elephant and the whale have met this problem, each in his own way, by developing its own "atomic" structure, its own organization. This organization is usually not evident except in synthetic organisms like an army. Here trial and error has developed efficiency in building up the "atomic" units in which the various problems of the existence and the functions of an army as a unified organism are solved. The same principle will hold true for a leaf or a city. There must be an optimum size for leaves under given conditions in which the movements of the sap are balanced against the loss of water by evaporation, for instance. In the case of cities, the problems of procuring supplies and removing wastes develop as limiting factors, not to mention other problems such as that of internal movement. Thus, Chicago is confronted with an immense sewage problem, while Los Angeles finds an adequate water supply an acute question, and New York is seriously limited in horizontal growth.

Many other examples might be cited, but these are enough to indicate that very likely the size of atoms in general is determined by mechano-geometrical considerations just as it appears to be in the chemical atom. In all cases, many factors are involved in determining the size of the unit, and it would be unwise to attempt to define them closely in any particular case at the present time.

From all the above, it is becoming clear that the problem of philosophy and of science at present is accordingly not that of restricting the use of the atomistic conception, but of broadening it into a more powerful tool in the development of more adequate conceptual models of things in general. Probably every worker who has yielded himself to the atomistic conception of things did so with a secret dread that he was going to lose something precious, but found himself in the end enriched and better able to visualize and understand the unit which he had dissected. Moreover, hav-

ing familiarized himself with the components, he is better able to understand that the unit is more than the sum of its parts. Thus, a physiologically normal salt solution is more than the sum of the salt and water of which it is composed. In general, even within the range of the so-called homogeneous systems of chemistry, the more complex a system is, the more properties it possesses and the more subtle some of them are even to the point of being indescribable and immeasurable. When we pass into the range of heterogeneous and colloidal systems, this becomes even more true. Consequently, it is easy to see why every thoughtful worker preoccupied with atomistic concepts is never unaware of the so-called "Gestalt" concept. He realizes that his atoms, whatever their scale, are composed of simpler atoms, and in turn constitute parts of larger, more complex atoms, and that any account that he gives of the atomic system in which he is interested at the moment is incomplete. In fact, the atomist is the only worker who is trained and equipped to understand the statement that the properties of a unit are never merely the algebraic sum of the properties of its component parts, regardless of the scale upon which these are defined. The properties of water are not merely the algebraic sum of those of hydrogen and oxygen. A man is more than the sum of the chemical substances of which he is composed or than the sum of his individual organs and tissues.

If we revert to the illustrations used in the introduction, it appears that the chemist, who by long experience has learned something about carbon, is better prepared to appreciate the beautiful crystal architecture of the diamond. His knowledge of carbon prepares him to appreciate the greater mysteries of the emerald and the pearl. The paint chemist knows just where the technical mastery of paint manufacture stops and the skill of the artist begins.

The danger that we appear to face in science, then, is not that of too much atomism, but rather that of not enough. Atomism has been a tremendously powerful intellectual tool in the conquest of our environment, but its successes have consisted in two steps—analysis and synthesis. If we stop at analysis, we are lost, and probably the warnings of our prophets were really directed against this—the error of going only half way through. But here again, the classical method of chemistry should help us. According to this method a problem is not solved until the analysis has been confirmed by the synthesis. This, after all, must be the final test of all atomistic conceptions—analysis followed by synthesis.

Finally, the writer is bound to say that if the reader has read this far and is not reduced to a state of profound humility at the sight of the work that remains to be accomplished, and at the same time inspired by a sense of power and courage at the comprehensive vision of what has already been done, then he has failed to follow the spirit of this essay. We stand as children with Newton on the shore of the sea of time and space, picking up a pretty shell or bit of coral here and there, but we are permitted to have the consciousness that the trifle that we have in hand bears some integral relation to the ocean of truth which lies beyond.

THE CHEMISTRY OF THE FORMATION OF POISONS IN PLANTS

By Lieutenant ROBERT E. SADTLER

MANY poisonous alkaloids, glucosides, toxins, toxalbumins and saponins occur in various species of plants. There are other chemical substances found in plants which are not strongly toxic but curative in their properties. Both classes of substances are products of plant metabolism or serve as reserve food substances. For example, hydrocyanic acid is regarded as the first product of nitrogen assimilation in the plant. These poisons also have a marked protective function to the plant. Many poisons occur in the insoluble form in the cell-sap, as morphin, atropin, digitalin, veratrin and muscarin, without injury to the plant. The physiological effect of various poisons upon different species of plants is variable, due to the variations in the constituency of the protoplasm of the plants. An alkaloid may act as a stimulant upon one plant and have a distinct toxic effect upon another plant of different species.

The toxic substance may occur only in the seed of the plant, and after germination the poison may be decomposed. In certain other plants, the earlier stages are non-toxic, but when it reaches maturity the poison is formed in the latex. This is the usual process in the formation of narcotic substances. In other cases, the poison is formed by the reaction due to the contact between two different tissues or parts of the same plant. Hydrocyanic acid is formed in this manner from the glucoside, amygdalin, by contact with an enzyme emulsion. Amygdalin occurs in the leaves of the cherry-laurel, and in the bitter almond.

The chemical activity of the individual vegetable poison is largely dependent upon the age of the plant producing it. The poison may be found in many different parts of the plant, as the stem, flowers, root, fruit, leaves or seed. Usually the poison found in aerial parts of plants is more transient than poison found in stem or roots. In certain cases, only the subterranean part of the plant is poisonous, as in the common European violet. Or the poison may be produced solely by the action of light, upon the subterranean part of the plant. An illustration of this is the green tuber of the potato.

Poisons are elaborated equally well both in deciduous and evergreen leaves. A thorough study of their relative toxicity, however, has never been made. The production of poison in plants is also dependent upon the following environmental factors: heat, light, season, soil, climate, fertility and culture. And of these factors, season, climate and cultivation, without question, play the greatest part in the formation of poison in plants.

Heat, when prolonged, causes dessication of the plant, evaporation of vital plant juices and volatilization of some of the poisons.

Light retards the growth of parasitic fungi and bacteria. Light also renders certain species of pathogenic bacteria quite innocuous. Certain poisons are formed only in the presence of light, and others only in darkness. Solanin ($C_{42}H_{75}NO_2$), a poison obtained from solanaceous plants, is produced only in the presence of light. Atractylin is another poisonous alkaloid produced only in darkness.

The amount of poison contained in the leaf and stem of a plant varies with the advance of the season. In some

plants, the poison passes from the leaves and becomes concentrated in the seed. Experimental work has shown that some plants are less toxic in summer than they are in fall, winter and spring. Plants which illustrate this principle are cowbane (*Cicuta maculata*), and musquash-root (*Cicuta vagana*). The fact has also been definitely established that plants lose much of their toxicity as they approach the flowering stage. The largest amount of acrid toxic substance is concentrated in the plant in spring. This has been shown by experiments with the opium plant and larkspur. However, there are some plants such as the mountain laurel which are most toxic in winter.

The content of hydrocyanic acid in plants also varies with the seasons. Experiments with the plane-tree have shown that the hydrocyanic acid content is greatest in young leaves. Experiments with other plants indicate also that as the poison becomes concentrated in the pod, the leaves become less toxic.

The exact part played by soil in the formation of the poisonous constituents of plants has not been fully determined. It is known that calcareous soils affect the color of certain poisonous plants and decrease their toxicity.

Climate has a significant influence upon plants, for example, cherry-laurel and aconite, which are poisonous in temperate regions, lose their toxicity when taken into colder regions. More poisonous species of plants are found in tropical regions than in colder zones, largely because of the heat and humidity.

The relative humidity of climatic zones affects the quantity and quality of vegetable poisons produced in the plant. Dry climates produce a greater amount of glucoside which can be converted into hydrocyanic acid (by hydrolysis) than moist regions. For example, the amount of alkaloid in the cola-nut varies with the climatic zone. The superior quality of certain kinds of opium is attributed to climatic conditions. These conditions also affect the amount of nicotin found in tobacco. The percentage of nicotin in tobacco varies from one half of 1 per cent. to 8.8 per cent., largely dependent upon soil and climatic conditions. Other chemical products of plants vary with climatic conditions also to a considerable degree.

Poisonous plants are usually very fertile. Culture of poisonous plants may eliminate the poisonous substance from the plant. Illustrations of this fact are seen in wild vetch and aconite, which when cultivated lose most of their toxic properties. Also certain forms of toxic bacteria, *e.g.*, *Streptococcus pyogenes*, lose their pathogenic properties when cultivated. However, there are many plants which retain their toxicity although they have been extensively cultivated for centuries.

Toxic substances usually have a wide distribution in related species of plants. For example, hydrocyanic acid varies from 2.2 per cent. in the kernels of fresh peach to 4.8 per cent. in the bitter almond.

There is also a wide distribution of toxic substances in plants that are not phylogenetically related. The irritant, glucoside poison, saponin ($C_{32}H_{54}P_{18}$), occurs in many different plants with widely varying botanical characteristics as quillaia and soap-wort.

Some of the most important families of plants having species which contain saponin are: Rutaceae, Sapotaceae, Saxifragaceae, Simarubaceae, Solanaceae, Tiliaceae, Araceae, Begoniaceae, Berberidaceae, Caryophyllaceae, Compositae (Arnica), Convolvulaceae, Dioscoreaceae, Euphorbiaceae, Filices, Graminae, Hippocastanaceae, Leguminoseae, Liliaceae, Loganeaceae, Myrtaceae, Oleaceae, Passifloraceae, Polemoniaceae, Polygalaceae, Primulaceae, Ranunculaceae, Roseaceae, and Rubiaceae.

The most important families of plants

containing glucosides yielding hydrocyanic acid are: Gramineae, Compositae (Briza, salt grass, wild rye, etc.), Ranunculaceae, Filices, Euphorbiaceae, and Saxifrage family. Of this last family, the most toxic plant is Jamesia or Rocky Mountain shrub.

One of the most important classes of vegetable poisons—the toxalbumins—are produced by the action of bacteria and fungi. Some of the most important of these poisons are found in the plant juices, as phallin, abrin and ricin, which occurs in castor-oil seed. Black locust is another important type of toxalbuminic poison.

The purpose of this paper has been to summarize the factors which produce poison in plants, and to state briefly some of the general principles of vegetable poison formation. I have also referred briefly to several poisons produced by bacterial action, and named some of the plant families in which certain specific poisons, like hydrocyanic acid, occur.

STUDENT HEALTH SERVICES AND MODERN MEDICINE

By Dr. J. HOWARD BEARD

UNIVERSITY OF ILLINOIS

THE progress of modern medicine is determined by three factors: a sufficient number of well-trained physicians, fruitful research and a public who appreciates the possibilities of medicine to serve it. The greatest of these three is an intelligent public, sympathetic with the medical profession and ready to give public health administration the necessary moral and financial support to make it commensurate with scientific knowledge.

MEDICAL TRAINING

There are approximately 149,521 doctors in continental United States, which is one physician to every 793 persons in the population. The total deaths in the profession during 1927 was 2,790. The number of graduates of medical schools for the year ending June 30, 1928, was 4,262, which, without allowing for the failure of the two periods to coincide, is a net gain of 1,472 doctors for the year.

In spite of the requirement of high-school graduation, two years' college education, four years' professional training and a year's internship to be eligible to practice, the number of students entering medical schools since 1919 has shown an increase of about 1,000 per annum. As only 17 per cent. of those matriculating fail to graduate, the steady increase in the number receiving the M.D. degree not only insures a replacement of the physicians who die or become inactive but it also provides for the annual addition to the population.

There is no shortage in physicians for the country as a whole, but there are certain irregularities in their location that are due to the social, educational, economic and professional advantages associated with density of population, rapid transportation and with the need of hospital and laboratory facilities in the practice of modern medicine. The rapid increase in the mileage of improved roads is making the town and country mutually more accessible and is doing much to relieve the rural sections of the disadvantages due to unequal distribution of doctors.

The above considerations are presented to emphasize the fact that, whatever its handicaps, modern medicine is not likely to be retarded in its progress

by the lack of a sufficient number of highly trained physicians to practice it.

Productive Research

The epochal contributions to medicine during the last fifty years prove that medical progress has not been seriously impeded by the want of discovery during the last five decades. Medical knowledge has increased more in the period from Pasteur to Banting than from the beginning of the practice of medicine by ancient priests to 1870. Research has been overwhelmingly prolific and its results revolutionary. The profession has been swamped with facts and technique until in self-defense its members have been compelled to limit their activities to escape superficiality and to make it possible to exploit adequately a particular field.

In brief, this is the story of the creation of the hundred and one specialties of medicine. Likewise, it is the history of productive investigation at the bedside, in the clinic, in the laboratory and in the great institutes of research. Today, discovery follows discovery with such rapidity that there appears to be no decrease in the fertility of research. There is no indication that medical progress will halt because of the failure of scientific investigation to mine new facts.

The Perplexity of the Public

If the profession has had to narrow its front to increase its depth and strength, what is the perplexity of the average layman when he contemplates medicine in its relation to himself, his family and his community? If it is true that the average citizen's knowledge of medicine is on the average three generations behind the profession, how out of date must be his medical conceptions when medicine has acquired more facts in the last five decades than in the previous five thousand years?

In the disparity between scientific knowledge and public information is found the explanation for such acts as that of a graduate of two universities putting a fly blister on his elbow to keep influenza out of his mouth, and that of the painter with a fourth-grade education on a city council defeating a model milk ordinance endorsed by the local medical profession, the surgeons-general of the army and U. S. Public Health Service and by the director of the State Department of Health. It also explains the reason for an outstanding financier glazing his home with costly special glass to protect his children against rickets when two minutes out of doors would be worth fifteen hours inside the house fifteen feet from the window.

It should cause no surprise when individuals otherwise known for their excellent judgment are found worshiping at the shrines of pseudoscience and unscientific medicine. Current periodicals portray the virtues of glorified antiseptics, the miracles wrought by yeast, the wonders accomplished by artificial light, the preposterous claims of the latest proprietary, food or fad, and by no means least the sylph-like beauty to be derived by maidens reaching for a cigarette instead of a sweet.

In such advertisements the truth is twisted cleverly to trap both the ignorant and the gullible. Such health appeals block the progress of medicine by filling the layman's mind with medical "bunk" and scientific "hooey." Neither medical training nor research can meet such a situation. Education alone is the solution.

The public is becoming more and more enmeshed by cults, "-isms," "-pathies" and therapies. In the year 1929, voodooism is reported to be wide-spread in some of the most prosperous counties of one of the oldest and most enlightened states of the union. Even murder is committed by its exponents to get a lock

of hair to bury eight feet underground to break a "spell."

Quackery has never been so high-powered, more able to deceive the average individual, more costly than to-day. The great developments of science in the last few decades afford it so many chances for new disguise in apparatus, method and formula that it has not only become a menace to health and the progress of medicine, but it takes millions of dollars annually from those least able to part with their money.

Though the truth is said always to triumph, the odds favor quackery. While a scientific fact is singular, fraud built about it may be multiple. It is easier to educate to buy than to teach to understand. Besides, mankind in general seems more resistant to truth than humbuggery. As medicine becomes more technical by the greater application of biology, physics and chemistry to diagnose, control and treat disease, only the searching rays of knowledge can save the public from the pseudoscience of the mountebank.

The Magnitude of the Task of Medicine

The mission of medicine is not only the alleviation of human suffering but it has the more sacred duty of promoting a national vitality and intelligence which shall make the nation immune to the forces of degeneracy and retrogression which laid waste the empires of the past. As Laycock has pointed out, man as compared with other animals is peculiarly predisposed to degeneration of the nervous system, and civilized man more so than his uncivilized brother. For this reason and for the fact that, with painful regularity, nations have risen only to decay, certain observers have seen in civilization the symptoms of disease whose end is national dissolution. If such views are correct, modern medicine has a challenge which will tax its every resource.

There are no more undiscovered continents in which civilization may be revitalized by pioneers developing a new life in a new world. The rejuvenation of nations by incursions of a more vigorous primitive people becomes unlikely with the greater development of communication, the intermixture of customs and world-wide recognition of national boundaries. As the center of population moves farther and farther into the city and rapid transportation makes the rural sections increasingly the suburbs of a metropolis, the countryside correspondingly loses its value as a producer of a bold peasantry able to give renewed vigor, "Where wealth accumulates and men decay."

National vigor must depend more and more upon the taking of thought. Man faces the issues squarely of whether or not he is capable of employing scientific knowledge in time and thoroughly enough to produce racial betterment, to insure each of his fellows sanitary living conditions and to obtain the health which qualifies him to live most and serve best.

While research has thrust upon two generations a mass of facts concerning heredity, the processes and development of life, the interrelationships of species and the possibility of advancing human welfare, greater than man has known since Adam left Eden, parallel development in the mechanical arts, in the use of electrical energy, in the application of chemistry and in transportation makes this extraordinary advancement only relative rather than phenomenal.

Two health problems have been produced for each one that industrialism and engineering have furnished the means of solving. Needs arise and opportunity knocks, but generations pass before the one is met and the other heard. If to this situation is added the usual long latent period between the acquisition of knowledge and its general use by the public, it is clear that modern

medicine faces a gigantic task in making its performance commensurate with its possibility.

The Trend of the Health Movement

From isolation practiced by the ancient Hebrews and later legalized as quarantine by the Venetians, preventive medicine entered an era of sanitation. From an epoch of "clean-up," it has become intimately personal. Therefore, its future depends upon the success of making every intelligent citizen an active public health worker, otherwise majority action to obtain individual benefit is impossible.

To-day the periodic physical examination and health education are declared to be the most hopeful means by which modern medicine can further increase the average expectancy of life, promote physical efficiency and insure national vitality. If such are to be its weapons in a new day to meet new conditions, there is no agency anywhere in a more strategic position to serve the public and to advance the progress of medicine than a student health service in an institution of higher learning. In their ability to serve society is the secret of the phenomenal development of these departments in universities, colleges and normal schools.

Student Health Services

A student health service is a health center within an institution of higher learning. It is dedicated to the conception that constructive dynamic living, in the best environment that modern science can provide, is the rightful inheritance of every individual. To attain this ideal it teaches the student the principles of hygiene and sanitation as they relate to him, to his home, to his vocation and to his community. Its methods are classroom instruction, the periodic physical examination, the personal conference, demonstration of disease control and the maintenance of sanitary surroundings. It strives to reveal to the leader of to-morrow the benefits to be derived from hospitalization, public health and modern medicine, because such knowledge will mean much to him, to his family, to his community, to diagnosis, to treatment, to the equipment and maintenance of hospitals and to national vigor.

It is the purpose of health services neither to pauperize nor paternalize students nor to socialize medicine, but to put the college graduate and the physician shoulder to shoulder to mutual advantage in serving society, in advancing scientific medicine and in making a better world.

THE PROGRESS OF SCIENCE

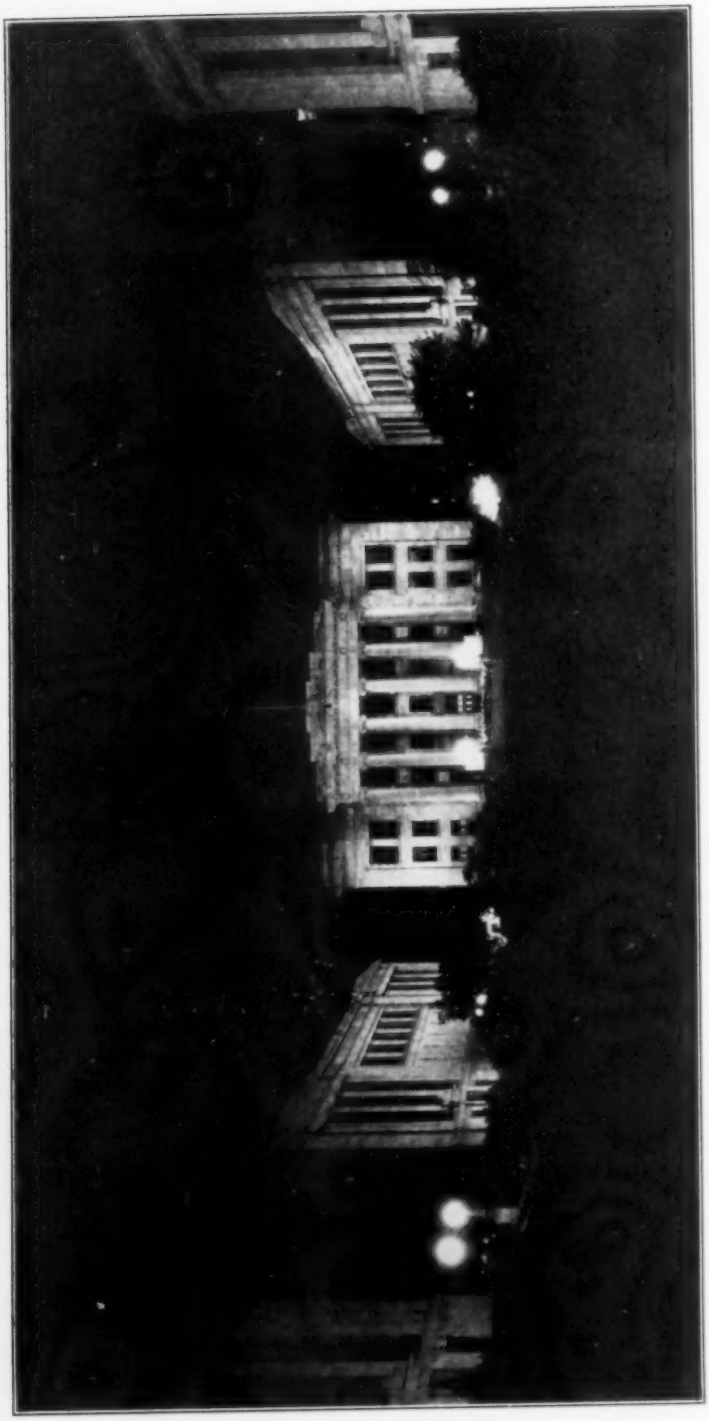
THE THIRTEENTH INTERNATIONAL PHYSIOLOGICAL CONGRESS AT HARVARD UNIVERSITY

INTERNATIONAL scientific congresses met but rarely in the United States before the war. Since the resumption of international relations there have been congresses of botany, agriculture and entomology; now congresses of physiology and psychology have been held here, the former at Harvard, the latter at Yale. These congresses were successful beyond expectation, most of all in the attendance from abroad, although the number of American members and the number of papers presented by them are also noteworthy. This is fortunate, for as one of the speakers is reported in the daily press to have said: "International congresses are significant factors in the advancement of scientific research; they also promote international cooperation and good-will. The objects of the sciences are more ideal than the objects of the churches; their practices are more Christian. When in the fulness of time there is a family of the nations, when each will give according to its ability and receive according to its needs, when war among them will be as absurd as it would now be for members of this congress to begin murdering one another, this will be due in no small measure to cooperation among scientific men of all nations in their common work."

The number of members registered at the Physiological Congress held at Boston and Cambridge during the third week of August eventually reached 1,654. This is more than twice as many as have been enrolled in any previous congress. Especially remarkable is the apparent fact that more Europeans were in attendance here than ever on their own continent. Of the registration reckoned above, 1,229 names were entered in season to be printed on the program. A rapid and approximate check-up brings out the following facts. The number from outside the United States and Canada is 530, 43 per cent. of the total. Germany leads with 94. France and England appear to be tied with 74 from each. Italy follows with 43; other countries in order are Austria with 28, Hungary 26, Russia 25, Belgium 20, Czechoslovakia 16, Holland 15, Spain 14, Sweden 13, Japan 11, China 10. The total number of countries comes to about 39—subject to variation according to one's judgment as to whether provinces and colonies shall be distinguished. The representation of Latin America was not large—about 13.

Analysis of the program shows that about 440 papers were given and 55 read by title. There were also some 78 demonstrations. As a rule, five or six sessions were progressing simultaneously, but by a well-contrived use of bulletin boards information was given in each room of the point reached in every other schedule; timely shifting was thus made easy. Of the papers read about 87 were in German, 47 in French and 18 in Italian. The general superiority in command of language manifested by our guests from abroad afforded food for reflection. A demonstration was given by Dr. Dusser de Barenne, of Holland, when he answered questions of Germans, Frenchmen and Americans each in their native speech. Even more impressive was the performance of Dr. Anrep when he swiftly rendered the Russian of Professor Pavlov into faultless English.

At the opening meeting, held in Sanders Theater, Cambridge, Surgeon-General Hugh S. Cumming, of the U. S. Public Health Service, gave an address of welcome on behalf of the United

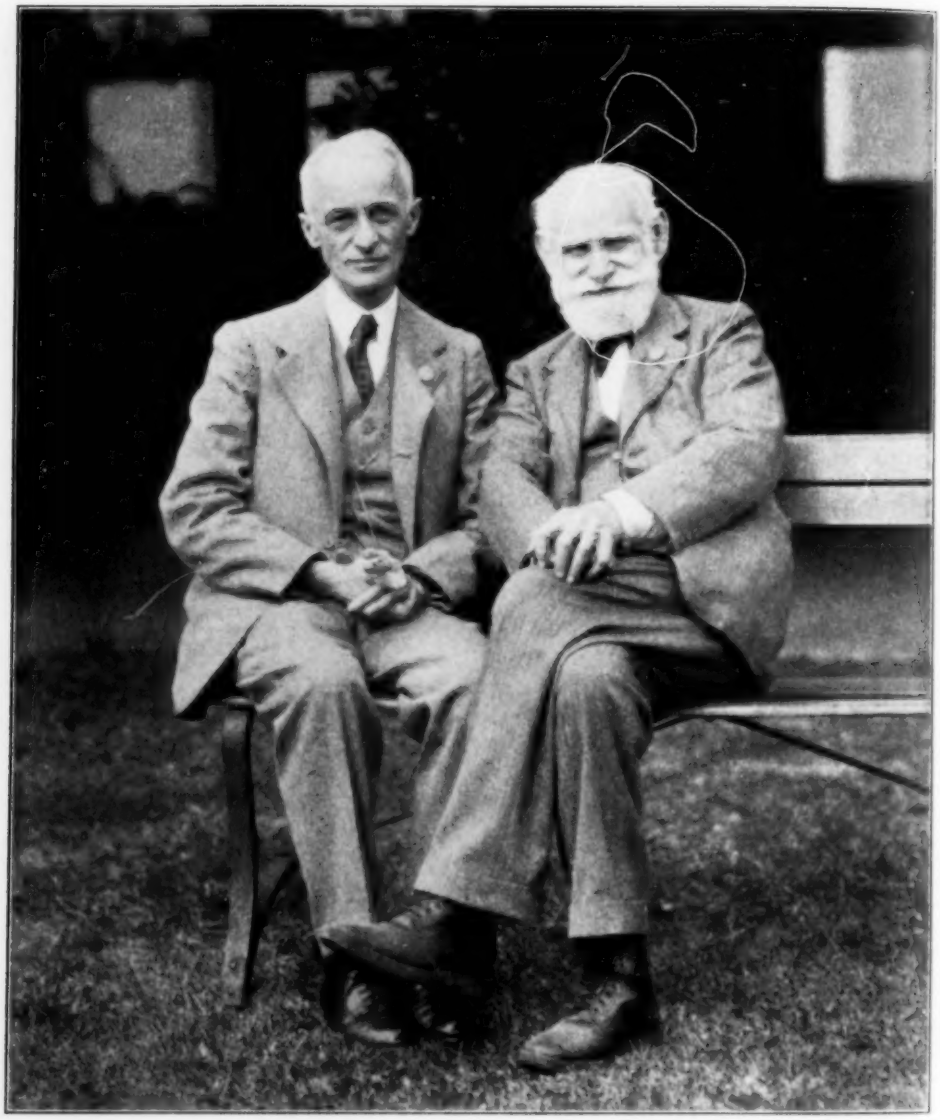


THE HARVARD MEDICAL SCHOOL

A PHOTOGRAPH TAKEN AT NIGHT ON THE OCCASION OF THE RECEPTION AND CONCERT OF THE BOSTON SYMPHONY ORCHESTRA, GIVEN IN HONOR OF THE THIRTEENTH INTERNATIONAL CONGRESS OF PHYSIOLOGY.

DR. WILLIAM H. HOWELL

PRESIDENT OF THE THIRTEENTH INTERNATIONAL PHYSIOLOGICAL CONGRESS. DR. HOWELL HAS BEEN PROFESSOR OF PHYSIOLOGY AT THE JOHNS HOPKINS UNIVERSITY SINCE 1888. HE IS NOW DIRECTOR OF THE SCHOOL OF HYGIENE AND PUBLIC HEALTH.



AT THE INTERNATIONAL PHYSIOLOGICAL CONGRESS

PROFESSOR PAVLOV, OF LENINGRAD, AND PROFESSOR CUSHING, OF THE HARVARD MEDICAL SCHOOL AND THE PETER BENT BRIGHAM HOSPITAL. PROFESSOR PAVLOV, A DISTINGUISHED MEMBER OF THE PHYSIOLOGICAL AND PSYCHOLOGICAL CONGRESSES, CELEBRATED IN SEPTEMBER HIS EIGHTIETH BIRTHDAY.

AT THE INTERNATIONAL PHYSIOLOGICAL CONGRESS

ON THE LEFT IS DR. REID HUNT, PROFESSOR OF PHARMACOLOGY AT HARVARD UNIVERSITY; IN THE CENTER, DR. ROSS G. HARRISON, PROFESSOR OF COMPARATIVE ANATOMY AT YALE UNIVERSITY; AT THE RIGHT, PROFESSOR W. H. HOWELL, PRESIDENT OF THE CONGRESS.

States government. He was followed by Lieutenant-Governor William S. Youngman who welcomed the members of the congress on behalf of the Commonwealth of Massachusetts. President A. Lawrence Lowell greeted the congress and welcomed it to Harvard University. The last of the addresses of welcome was delivered by the president of the congress, Professor William H. Howell, of the Johns Hopkins University. An address on "The Progress of Physiology" by Professor August Krogh, of the University of Copenhagen, was delivered following the addresses of welcome. Professor Krogh is director of the Zoophysiological Laboratory at the University of Copenhagen and a Nobel Prize winner for his work on the physiology of the capillaries. The formal dinner was presided over by Professor W. B. Cannon, of the Harvard Medical School. The 1,600 in attendance exceeded the capacity of Memorial Hall and overflow dinners with loud-speakers were necessary. At the closing exercises an address entitled "Reminiscences of the Early Days of the Physiological Con-

DR. JAMES ROWLAND ANGELL

PRESIDENT OF YALE UNIVERSITY AND VICE-PRESIDENT OF THE INTERNATIONAL CONGRESS OF PSYCHOLOGY. DR. ANGELL WAS PROFESSOR OF PSYCHOLOGY AT THE UNIVERSITY OF CHICAGO FROM 1894 TO 1920.

PSYCHOLOGISTS AT YALE UNIVERSITY

gresses'' was delivered by Professor Léon Fredericq, president of the Second International Congress, which was held in 1892 in Liége, where he is now professor emeritus.

It has been of interest to analyze the list of communications with the object of finding out whether particular subjects are receiving unusual attention. One might guess that this would prove true of the endocrine system, vitamins, the effects of radiant energy and electrophysiology. But when the tabulation is made the distribution seems to be remarkably impartial. If the chapter headings from a standard text were used to classify the titles there would be no disproportionate massing under any of them. There are workers in every field and they do not migrate in large numbers. One subject at least—H-ion concentration—does not loom so large as it did in programs of a few years ago. Moreover, many must have found it a heartening fact that a goodly proportion of the papers were frankly qualitative. Evidently there is still work for the non-mathematical physiologist.

The social features of the congress were memorable. Perhaps the scene which will most often be recalled was that presented by the great court of the Harvard Medical School on Wednesday evening. No setting could have been more stately or befitting the occasion. There was a soft and uniform illumination of the marble walls, with orchestral music. When the moon topped the copings a guest said to Dr. Cannon: ''That is the only thing about all this that seems real.''

PSYCHOLOGISTS AT YALE UNIVERSITY

A GROUP TAKEN IN ONE OF THE COURTS OF YALE UNIVERSITY SHOWS PART OF THE PSYCHOLOGISTS ASSEMBLED. SEATED IN THE FRONT ROW ARE MEMBERS OF THE AMERICAN NATIONAL COMMITTEE. BEGINNING AT THE CROSS ON THE LEFT ARE PROFESSOR ANGIER, OF YALE, CHAIRMAN OF THE LOCAL COMMITTEE; PROFESSOR LANGFELD, OF PRINCETON, FOREIGN SECRETARY; DR. ANGELL, PRESIDENT OF YALE AND VICE-PRESIDENT OF THE CONGRESS; DR. CATTELL, PRESIDENT OF THE CONGRESS; PROFESSOR WASHBURN, OF VASSAR; PROFESSOR PILLSBURY, OF MICHIGAN; PROFESSOR WARREN, OF PRINCETON; PROFESSOR BENTLEY, OF CORNELL; PROFESSOR HUNTER, OF CLARK, EXECUTIVE SECRETARY; PROFESSOR BORING, OF HARVARD, SECRETARY; PROFESSOR ANDERSON, OF MINNE-

THE NINTH INTERNATIONAL CONGRESS OF PSYCHOLOGY AT YALE UNIVERSITY

THE International Congress of Psychology met at Yale University from September 1 to 8, with a total attendance of 1,051. Of these 123 were from abroad, Canadians and Mexicans being counted as Americans. There were present 722 members and associates of the American Psychological Association, which is a remarkable record, for the association has in all 893 members with about 200 recommended for membership and included among those to whom invitations were sent. There were, in addition, 271 American members who were unable to be present, so the total membership was 993 from about 1,100 American psychologists. The situation thus differs from that of the Physiological Congress where foreign members and foreign papers were relatively more numerous. This, however, represents the international situation, for fully one half the psychologists of the world are Americans. In one of the papers presented at the congress it was shown that among the contributions abstracted in *Psychological Abstracts* during the past two and a half years, 5,449 were from

PSYCHOLOGISTS AT YALE UNIVERSITY

SOTA; PROFESSOR LASHLEY, PRESIDENT OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION; PROFESSOR PAVLOV, OF LENINGRAD; PROFESSOR DODGE, OF YALE, CHAIRMAN OF THE PROGRAM COMMITTEE. IN FRONT OF THOSE JUST MENTIONED ARE THREE OTHERS OF THE NATIONAL COMMITTEE, PROFESSOR SEASHORE, OF IOWA; PROFESSOR FERNBERGER, OF PENNSYLVANIA, AND PROFESSOR THORNDIKE, OF TEACHERS COLLEGE, COLUMBIA. STANDING ABOVE ARE FOREIGN MEMBERS OF THE CONGRESS; PROFESSOR CLAPARÈDE, OF GENEVA, PERMANENT SECRETARY OF THE INTERNATIONAL CONGRESSES, AND MME. CLAPARÈDE BEING MARKED WITH AN O.

the United States, 1,549 from Germany, 836 from Great Britain and its dominions, 811 from France, 218 from Italy, 149 from Russia and 371 from other nations. There were presented before the congress about 360 papers by Americans and 97 papers by foreign members.

The American members were from 42 states and from Porto Rico, Canada and Mexico. New York led with 196, followed by Massachusetts 80, Illinois 42, Pennsylvania 40 and Connecticut 39. Twenty-one foreign countries were represented, those with five or more members being England 22, Germany 17, Soviet Russia 10, Netherlands 8, India 6, Austria, France, Switzerland and Japan 5 each. Special invitations were sent to foreign nations through our Department of State. It is unfortunate that South America was represented by only one member.

At the opening session the members were welcomed to Yale University by President Angell, at the same time president of the university and vice-president of the congress. The foreign members were welcomed to the United States by Dr. William John Cooper, commissioner of education, who was summoned by telegram from Alaska by President Hoover to perform this office. The address of

PSYCHOLOGISTS AT YALE UNIVERSITY

the president, Dr. J. McKeen Cattell, was then given on "Psychology in America." There were but few formal meetings or entertainments at New Haven, but the arrangements for lodging in the beautiful Harkness dormitory and for meals in University Hall gave the best possible facilities for social meetings.

The program differed from that of the physiologists in that there were each evening two lectures given by distinguished foreign members with one American, Professor E. L. Thorndike, and on one evening the address of the president of the American Psychological Association, Dr. Karl S. Lashley, now of the University of Chicago. There were usually three sessions in the morning for invited contributions, papers from foreign members here predominating. In the afternoon there were numerous simultaneous sections at which all psychologists who had research to report were given an opportunity. The discussions at these sections, often confined to a relatively small and definite field, were of special interest.

Arrangements for the entertainment of the foreign guests were not limited to the meetings at Harvard and Yale. Many of them were provided with lecture engagements before and after the congress which assisted in defraying the expenses of travel. For example, six state universities arranged to have as part of their summer sessions a course on psychology given by six distinguished foreign psychologists, each visiting the university for a week. After the Physiological Congress the foreign members were taken to Woods Hole by motor bus and then by boat to New York where a whole week was given to entertainments, excursions and visits to scientific institutions. An excursion was then made to Canada. The foreign psychologists were entertained before the congress at Princeton and Columbia and afterwards at Harvard, with trips arranged to Smith College, Clark University and Woods Hole.